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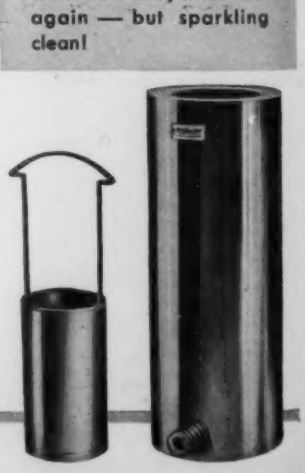

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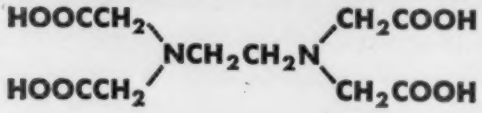

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The Class of '02

COLLEGES and universities customarily boast about distinguished alumni, and it is not inappropriate—or unbecoming—for the AAAS to boast a little about its older members. When the names of those scientists who are completing their fiftieth year of continuous membership in the Association were read at the Bloomington (Indiana) meeting of the Executive Committee, it was unanimously voted to pay tribute to them in the pages of SCIENCE.

There are 67 who joined the AAAS in 1902. Three of them are women. All but three of the number contributed so substantially to their respective fields of science as to have earned the rank of Fellow—not that this is especially important, because fifty years of membership reflects a sustained interest that is, in itself, a contribution to the advancement of science.

An analysis of the group would unquestionably be rewarding, but in this brief tribute only superficial impressions can be imparted. If it be assumed that all of them entered the Association at the tender age of twenty-five, each one would be seventy-five years old. Nearly three quarters of them have led academic, but not necessarily ivory-towered, lives—witness Anton J. Carlson, president of the Association in 1944. Nearly all have retired from teaching, but not from research, as the current work that Albert F. Blakeslee, president of the Association in 1940, is doing in plant genetics amply demonstrates. A few, like George B. Pegram, of Columbia University, are only now passing heavy administrative burdens on to younger shoulders.

At least seven of the 67 have given their talents to government agencies, although Austin H. Clark had plenty of energy and ingenuity to aid the AAAS in its first efforts to inform the public about scientists and their research. Of the other six, five are geologists, including W. C. Mendenhall, former director of the U. S. Geological Survey and immediate predecessor of the present treasurer of the AAAS. Rudolf Ruedemann, who served the New York State Museum as paleontologist for many years, is the only representative of the state surveys, for George H. Ashley, long state geologist of Pennsylvania and also a member since 1902, died at the age of eighty-four on May 28.

One is tempted to speculate on the secret of longevity, but it is obvious that the profession of scientist per se is not the answer. During the past five months SCIENCE has reported the deaths of 330 scientists and engineers whose ages were known. The average age was 68.3—a figure that indicates simply that the scientist may expect to live until he approximates the standard threescore years and ten. Distribution by fields of specialization is interesting but inconclusive, for there is no information as to the proportions of members among the several sciences in 1902. It may, however, be noted that 13 were zoologists, 12 geologists, 11 chemists, 9 botanists, 7 physicists, and 6 members of the medical profession. The natural scientists, or naturalists, might claim superior survival characteristics from these fragmentary statistics, but the claim cannot be scientifically supported.

Had this note been written by a science writer, it would have been headlined differently, and its entire content would have been subordinated to the headline member of the Class of '02. Had it been prepared by a novelist, the element of suspense would have been introduced much sooner. The group's most distinguished figure virtually abandoned the engineering profession many years ago, though he never ceased to use its exacting principles or to observe its rigid standards in public life. He even lists engineering as his second choice among the Association's sections—his first is Section K, the social sciences. He is Herbert Clark Hoover.

HOWARD A. MEYERHOFF
Administrative Secretary

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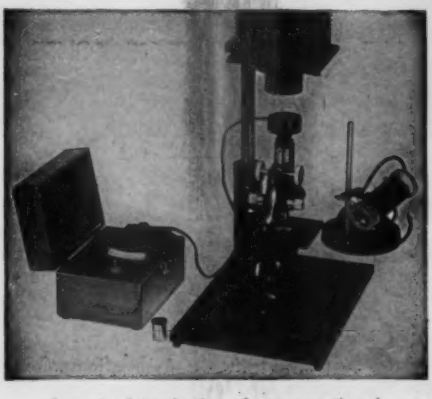

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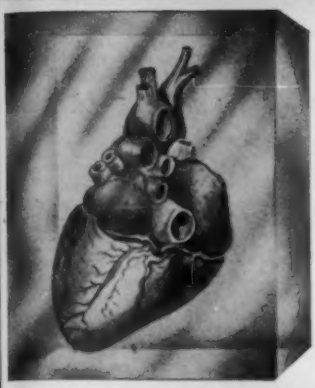

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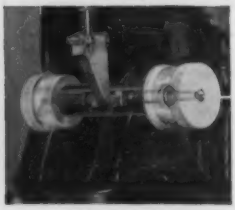

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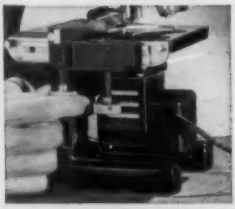

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Differential Systematics

William H. Womble[1]

Department of Anthropology and Sociology, University of California, Los Angeles

Classification, Arbitrary and Natural

CLASSIFICATION is certainly as old as language, for categories are basic to vocabulary. In a sense it originated with reacting organisms. Even the ameba, responding differentially to a varied environment, effectively orders its own world. Surely so ancient and universal an activity, vital alike to primitive hunter and modern urbanite, should have been developed to a precise technique. Yet it is not uncommon for different students of the same phenomena to arrive at altogether incompatible taxonomies, which at times seem to be evaluated more by the reputations of their authors than on their approximation to reality. Observational science still is founded on an imperfect art. Empiricism appeals to a new authoritarianism.

Taxonomy occasionally perplexes most scientists, but it persistently harasses the biologist. Consequently, he has acquired a thorough familiarity with the problem, if not a satisfactory solution of it. In presenting a new approach to systematics, we shall draw largely on life sciences for illustrative materials, although the principles to be developed are applicable to other fields as well.

Biologic classification pivots on the species concept—or concepts, since there are several. According to Mayr (*1*): "Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." Although relevant only to contemporary, sexually reproducing forms, this definition, based on breeding patterns as found in nature, possesses clear theoretical advantages. The practice of distinguishing species by degree of morphological difference is purely arbitrary, and the test of hybrid sterility lumps together many diverse types that normally intermingle without interbreeding, or produce hybrids inadequate to natural competition. In Mayr's biologic interpretation, species are genetically interacting universes. In their response to differing selective environments, or their divergence through genetic drift or mutation, they develop distinguishing traits, any of which may serve as diagnostics. Yet, essentially, it is not the differences, but the mechanisms facilitating them, that are definitive. Through their reproduction habits and potentials, contemporary sexual species are natural, self-defining classes.

[1] The writer gratefully acknowledges receipt of a grant from The Wenner-Gren Foundation for Anthropological Research, Inc. Space does not permit mention of all contributors to the ideas developed here, but particular thanks are due Joseph B. Birdsell for many helpful suggestions and constructive critiques.

Larger taxonomic units are highly arbitrary. To be sure, if we examine a phylogenic tree, we note that any two species are related through a common stem or limb or crotch. But for what time span does this connection indicate the same genus? The same family? The same order? Splitters and lumpers engage in a continuous war of nerves over questions that are purely matters of definition. The phylogenic tree in itself constitutes the clearest and most exact supraspecific systematic.

Successional classification appears even more confused and confusing. Through geologic time, the same lineage changes in species, in genus, in family. If new forms customarily originate through single macromutations, then the traditional systematic is correct in principle. But if, as seems more probable, evolution usually proceeds through the slow grinding of the mills of selection on countless micromutations, then we must conclude that phylogenetic taxonomy reveals more concerning the accidents of paleontological discovery than of the realities of genetic change.

The data never seem adequate for a clear sequential systematic, but with respect to the subspecific taxonomy of contemporary species, especially the racial classification of man, much information has been collected, and more is available; yet the situation is equally chaotic. Neighboring populations of the same species ordinarily are distinguishable only by small differentials in a great many hereditary traits. Numerous authorities, employing different diagnostics, or diverse racial ranges in the same diagnostics, have produced competing taxonomies with little in common but their arbitrariness.

The embarrassment of both successional and subspecific classification is due, in part at least, to deficiencies inherent in a logic of classes. Discrete entities may be practically self-defining, but continuous variables, in space or in time, resist internal partition. The student of evolution in particular is hampered by the limitations of categorical reason, for dynamic processes must be sought, not in the differentiated, but in the differentiating.

Variety Differentiation

Nature is the first systematist and the only unassailable authority. If other taxonomists have the effrontery to rework her notes, it is only because the detailed complexities in which she records them are beyond ready human comprehension. Yet anyone attempting a simpler approximation to reality may well study the methods by which the fussy old lady works out her varieties.

Consider a species occupying a continuous range. Assume that, at some given time, a few populations exhibit a trait expression or gene frequency greater or less than the species mean (Fig. 1*a*). If hybridization were the only genetic process in operation, the exchange of genes between adjacent groups would, in time, erode these features of the trait topography and equalize population averages (Figs. 1*b*, *c*, *d*). Paradoxical though it seems, sexual reproduction, responsible for most individual differences through chance gene combinations, also promotes a spatial homogeneity analogous to physical entropy.

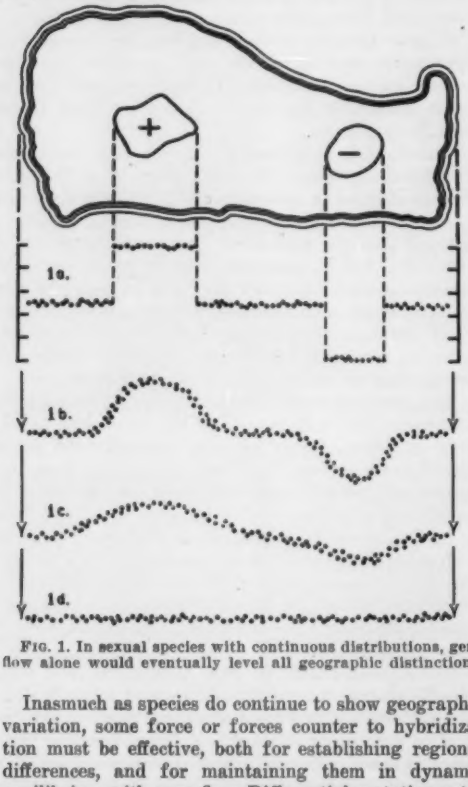

FIG. 1. In sexual species with continuous distributions, gene flow alone would eventually level all geographic distinctions.

Inasmuch as species do continue to show geographic variation, some force or forces counter to hybridization must be effective, both for establishing regional differences, and for maintaining them in dynamic equilibrium with gene flow. Differential mutation rates do not provide an adequate answer, for the rate differences themselves require explanation. Although successful new mutations establish flow fronts through the range of a species, such distinctions, unless fixed by other processes, are, in the long-term view, necessarily transitory.

Genetic drift may account for local differences while isolating mechanisms are effective, but these variations should randomize over any considerable area, and in any case they are swamped out with the reestablishment of gene flow. Only where large isolates are long maintained, or small groups migrate and subsequently populate broad territories, does it seem probable that drift is operative in major variety formation.

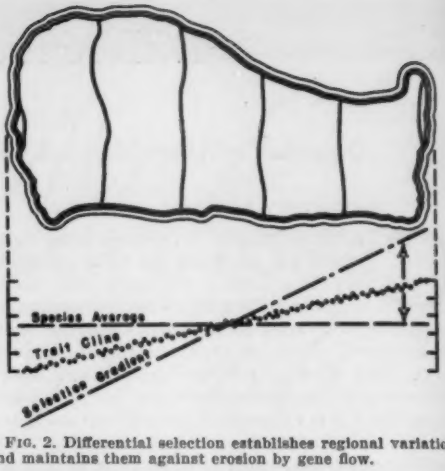

FIG. 2. Differential selection establishes regional variations and maintains them against erosion by gene flow.

Selection remains—not in the sense of a generalized force driving living organisms to a hypothesized future perfection, but as a specific mechanism for local adaptation to a differentiated environment. Consider a variable trait, quantifiable by metric, index, or gene frequency. If selection alone were operative, in time every local population would approximate that average trait expression most successful at its locus. A schematic plane, covering the species range and passing through the local values of maximum adaptation, has been defined as the *selection gradient*.

With a gradient of uniform slope (Fig. 2) the trait expression is caught in a tension between selection, drawing it toward local adaptive values, and gene flow, tending to reduce the species to spatial uniformity. The resultant trait cline may be a function of several variables, such as slope of the selection gradient, effectiveness of selection, numbers of gene

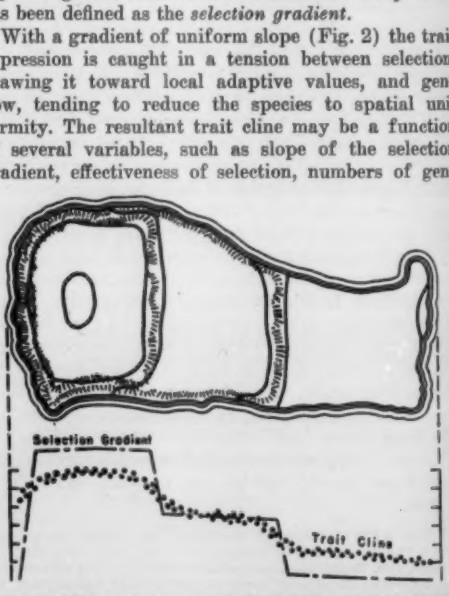

FIG. 3. Sharp environmental distinctions produce stepped selection gradients, which generate stepped trait clines.

loci and alleles involved and their relative dominance, inherent variability of the trait, mutation rates, and—of particular significance for this discussion—the relation between the geographic extent of the species range and the rate of gene flow across it. Rapid gene exchange and small ranges result in geographic homogeneity. Slow flow over broad and diverse areas favors regional differentiation.

Fairly smooth clines, varying with some aspect of the environment, are reported. Tongue lengths of European honey bees have been expressed as a linear function of latitude, whereas the relative size of their wax glands seems to vary with temperature (*2*). Within half a century of their introduction, the size of English sparrows in the interior United States differentiated with respect to climatic zones, the larger birds being favorably selected in areas of rigorous winters (*3*).

Numerous traits in many species, however, show stepped clines. One explanation is a similar and even more pronounced stepping in the selection gradient (Fig. 3). Thus, abrupt changes in ground color over large territories, in conjunction with flying predators, are highly effective in differentiating the coat color of rodents; but smaller areas of distinctive soils may not establish local types because of population infiltrations from surrounding regions (*4, 5*).

Stepped clines are also possible with constant selection gradients (Fig. 4*a*). If, in consequence of relatively sparse population or hindrances to communication, zones of reduced gene flow intersect the species range, the spatial genetic structuring of groups between the obstructions approaches that for distinct species. Since effective geographic extension is reduced relative to the rate of gene exchange, the trait clines are locally flattened. Inasmuch as the diminished genetic interaction between provinces exerts little influence for the maintenance of species unity, trait averages of the partial isolates approach local values of the selection gradient. Consequently, the clines must steepen through the barrier zones, which constitute the weakest threads in the genetic fabric. Should geographic isolation become complete, clines would show discontinuous steps (Fig. 4*b*). Regional trait expressions, completely freed from species ties, would find equilibrium at maximum adaptive values.

When barriers are removed, gene flow may re-establish species continuity, first producing stepped trait clines, and later even gradients. Or an insular group, through loss of variability, overspecialization, or failure to keep pace with evolution in other areas, may be eliminated in the ensuing intertype competition. If, however, during geographic isolation, biologic isolating mechanisms (such as hybrid sterility, changes in mating season or courtship patterns, etc.) develop between the separated groups, then the removal of geographic barriers does not result in effective hybridization. Each type may be so well adapted to its home environment that the others cannot displace it, although in the territory of each there are often local areas best suited to its competitors. Consequently, the ranges of such groups may overlap, yet the types remain distinct, thus demonstrating complete speciation (Fig. 4*c*).

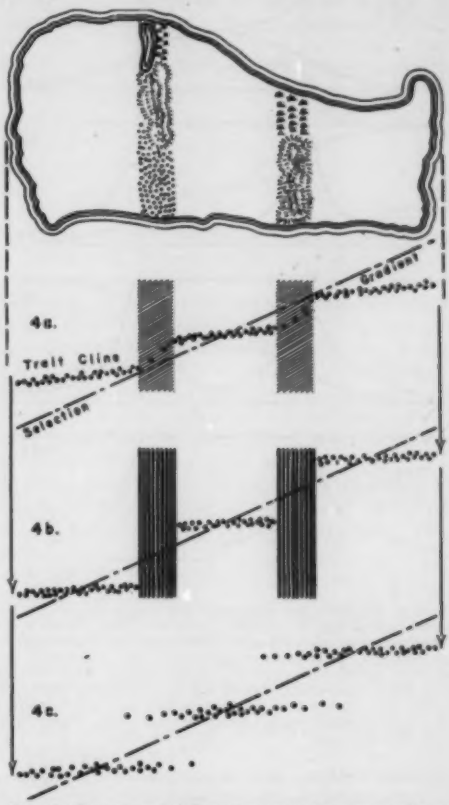

FIG. 4. The role of differential gene flow in variety and species formation: 4*a*, Zones of relatively reduced gene flow may produce stepped trait distributions, even with selection gradients of constant slope. 4*b*, Complete isolation results in discontinuous stepped clines with easily recognizable varieties. 4*c*, If biologic isolating mechanisms develop before the removal of physical barriers, former varieties may interpenetrate each other's ranges without hybridizing, demonstrating speciation.

If factors of lesser evolutionary importance are ignored, the formation and maintenance of geographic varieties in sexually reproducing animal forms are resultants of the interplay of gene flow and local selection. A regional adaptive differential (past or present) would seem to be the first requisite to a consistent regional trait differential. Thus selection, so effective in eliminating deviants from local natural populations, also is the prime mover of geographic variation. This is the obverse of our previous paradox concerning the role of sexual reproduction in promoting spatial homogeneity while producing individual differences. Uniform gene flow partially obscures the effects of pronounced features of the selection gradients on the trait clines; but if gene exchange is itself

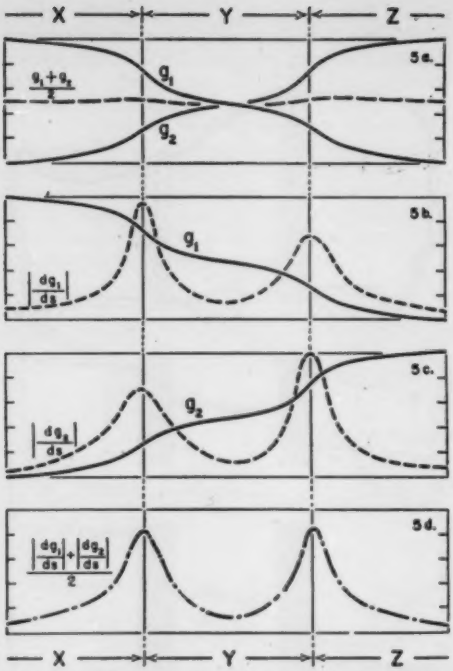

FIG. 5. Profiles demonstrating the synthesis of multiple variable traits into a composite derivative: 5*a*, Traits g_1 and g_2 show clines of opposite slope. Averaging them only confuses the picture of the evident varieties *X*, *Y* and *Z*. 5*b*, The absolute value of the derivative of g_1 is determined from the slope of its cline. 5*c*, The derivative for g_2 is similarly developed. 5*d*, The two derivatives (and those for any other traits as well) are averaged as a composite derivative. Peak values divide the varieties.

regionally differentiated, this pattern is stamped on clines generated by other processes.

Composition of Multiple Variables

As with specific, so with subspecific differentiation the more basic evolutionary reality lies, not in trait values in themselves, but in the genetic structure of which they are symptomatic. The species, constituting a universe of gene interaction, is seldom, if ever, homogeneous through time and space. Normally, various sized clumpings of nearly like populations are separated by stress zones or transition periods of differing extent and intensity. It must be the task of any adequate "natural" systematic to assay this structure, not only with respect to the spatial and temporal loci of similarities and differences, but also as to their relative degrees.

Huxley (*6*) has pointed out that species with a single reported varying characteristic, distributed in a continuous, uniform gradient, may be described as occupying a cline between the terminal populations. If the cline is stepped, one may designate geographic varieties, their boundaries falling in zones of steepest slope, although a more accurate definition is provided by the cline profile or, still better, a map with isophenes or isogenes drawn through loci of equal trait expression.

Three or four differing characteristics might be grasped in this manner without confusion, but well-studied species show too many variations to readily keep them all in mind at once. Our problem is to synthesize any number of such continuous variables into a single composite that shall closely approximate the natural differentiation of the total heredity. To facilitate comparisons, we recalculate the values of each trait to a scale from zero to one, representing the minimum and maximum population averages within the species for each measurement, index, and gene frequency employed in the analysis. For simplicity, we first consider in profile the clines for only two traits, g_1 and g_2, defining three evident varieties: *X*, *Y*, and *Z* (Fig. 5*a*). The mean value $\frac{g_1+g_2}{2}$ seems more to conceal than to reveal these distinctions. However, both the generalized effect of the intraspecific differentiation of gene flow on all trait distributions and the indirect action of selection gradients on the total genetic balance of the organism establish a common tendency for clines to steepen in the same zones. Therefore, even with gradients inclined in opposite directions, there is a good probability that the high and low absolute values of their slopes will coincide in geographic locus (Figs. 5*b*, *c*). Consequently, it is reasonable to average them as a mean derivation:

$$\frac{\left|\frac{dg_1}{ds}\right| + \left|\frac{dg_2}{ds}\right|}{2}.$$

As may be observed (Fig. 5*d*), peaks of this curve effectively bound the geographic varieties.

Of course, any number of trait derivatives may be so combined into a composite. If desired, a weighting factor w may be applied to each cline slope before summation, provided it is also represented in the denominator:

$$\frac{\sum_n w_i \left|\frac{dg_i}{ds}\right|}{\sum_n w_i}.$$

Although this introduces arbitrary judgments as to the relative importance of the traits (which might, for example, be based on estimates of the numbers of gene loci involved in their expressions), the resultant weighted average slope may more closely approximate the genetic reality than if the equally arbitrary assumption of trait equality is implicitly accepted. Because of sampling problems, it is preferable to exclude rare traits and those with little normal variability from the analysis. Otherwise, the more gene frequencies and truly independent biometric measurements and indices included in the development of the composite derivative, the greater is the probability that the latter will closely approximate the change with distance of the total genetic reality.

A profile analysis is adequate for shoreline and river organisms, but most species are found in area distributions. It is advisable, therefore, to develop techniques applicable to geographic space. As previously noted, each variable is related to a scale from zero to one. Values for each trait are separately plotted as isogenes or isophenes. Since the vertical contour interval Δg_i is known, and at any point M the minimum horizontal distance between adjacent contours Δs may be scaled from the map, the former may be divided by the latter to define the maximum slope of a straight line through the point and the two contours. With reasonably close intervals and no abrupt changes in gradient, this sufficiently approximates the maximum slope of the trait topography at M (Fig. 6a). Distance is measured in kilometers. A multiplication constant of 10,000 produces more convenient values for mapping widespread species:

$$\left|\frac{dg_i}{ds}\right|_M \doteq \frac{\Delta g_i}{\Delta s} \underset{\text{def}}{=} \frac{10{,}000 \times \text{trait difference}}{\text{distance in kilometers}}.$$

These calculations are not difficult, but they may be dispensed with in practice. The maximum slope at any point on a trait topography can be approximated directly from a reciprocal scale laid along the shortest line between adjacent contours (Fig. 6b). Such a scale may be constructed by multiplying the contour interval by 10,000 and dividing the product by the values of the map kilometer scale (Fig. 6c).

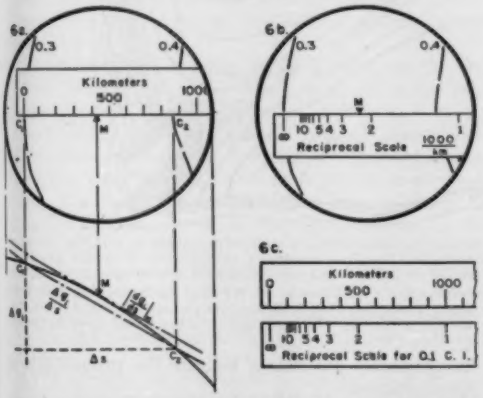

FIG. 6. Approximation of trait derivatives from contoured distributions: 6a, The contour interval Δg_i is given, and the space interval Δs may be scaled from the map. $\frac{\Delta g_i}{\Delta s}$ usually approximates $\frac{dg_i}{ds}$ at the midpoint M. Trait values scale from zero to one. Distance is measured in kilometers. 6b, The slope of a trait topography may be read directly from a reciprocal scale. 6c, Relation of reciprocal scale to map kilometer scale and contour interval.

Now all tools necessary for the composition of multiple variables in area distributions are at hand. From a contour map of any gene frequency or phenotypic expression (Fig. 7a) slopes at convenient map coordinates are read from the reciprocal scale. Results are plotted as isoclines of the trait derivative (Fig. 7b). For each of any number of other traits (Fig. 7c) derivatives are similarly developed (Fig. 7d). Isocline values for each trait are now multiplied by its appropriate weighting factor. At each suitable locus, all the weighted trait derivatives are summed and divided by the sum of the weighting factors. Finally, these values are plotted as isoclines of a composite derivative (Fig. 7e). This we define as the systemic function *Syf*:

$$Syf \underset{\text{def}}{=} \frac{\sum_n w_i \left|\frac{dg_i}{ds}\right|}{\sum_n w_i}.$$

The systemic function measures the weighted average change with distance of the trait clines. To the degree these are representative of all differentials in the species, the composite approximates the spatial variation of the totality. Ridge lines in the topography of this function indicate zones of relative disjunction, and so mark natural boundaries for the geographic varieties. Although the subspecific groups are not determined by diagnostics but by average rates of change for any number of variables, once defined they may be characterized in terms of trait averages. For uniformity, mean values for populations in the lower one half, by area, of each valley or basin in the systemic topography are accepted as typifying their groups.

Although we have determined the boundaries of subspecific units with reasonable objectivity, we still have not produced a classification. All ridges are not equally well defined. Which mark primary divisions and which secondary and tertiary? To approach the question from a different direction, in a finely detailed topography there are basins within basins of every magnitude. What area or population constitutes a variety? A subvariety? A local variant? These problems are not rooted in the reality, whose differentiations are manifest from the systemic topography. They spring from the inadequacy of taxonomy for dealing with continuous variables. Not only must a classification classify its phenomena; it must also classify its own classes—and this is often necessarily arbitrary. However, since everything a classification could reveal concerning the species structure is readily apparent from an examination of the mapped composite—and more besides—there seems little point in concerning ourselves with formal classes. We can circumvent the limitations of taxonomy by circumventing taxonomy. There is no objection to labeling conspicuous features of the topography for verbal convenience, but this is extraneous to the ordering of the reality. The systemic function *is* the systematic.

Systemic Space and Systemic Time

For convenience, the *systemic difference* ΔSy between two varieties v_1v_2 is defined as 10,000 times their average weighted trait differences[2]:

[2] Throughout this discussion, superscripts are designators, not powers.

FIG. 7. Development of the systemic function: *7a*, Isogene or isophene contours are mapped for trait g_1. *7b*, The slope of the trait topography for g_1 is measured at convenient map coordinates and isoclines are drawn through points of like gradient. *7c*, Each succeeding trait $g_{2,3,4,\ldots,n}$ is contoured. *7d*, Isoclines are developed for each such biometric measurement, index, and gene frequency included in the analysis. *7e*, The topography of a composite derivative is constructed by averaging the trait derivatives. (Weighting factors w_i may be employed where desirable.) This composite is defined as the systemic function *Syf*. Its ridge lines bound the geographic varieties. At any locus this variable evaluates the geographic homogeneity and heterogeneity of the species.

$$\Delta Syf_{v_1 v_2} \underset{\text{def}}{=} 10{,}000 \frac{\sum_n w_i \left| g_i v_1 - g_i v_2 \right|}{\sum_n w_i}.$$

Adjacent groups normally are more similar than those widely separated, unless there has been mass migration. Then an intrusive population may, for some time, show closer kinship with its previous neighbors than with its new ones. To highlight such cases, deserving more detailed attention, the intervarietal systemic slope may be calculated for all pair permutations $v_j v_k$:

$$\frac{\Delta Syf_{v_j v_k}}{\Delta s} = 10{,}000 \frac{\sum_{i=1}^{n} w_i \left| g_i v_j - g_i v_k \right|}{\Delta s \sum_{i=1}^{n} w_i}.$$

Exceptionally low values indicate the probability of recent contact.

Although intertype differences and gradients are useful in some analyses, they ignore the genetic situation between the type centers. Birdsell (*7*), working with Australian aborigines, has defined genetic distance in terms of the number of isolate boundaries between any two areas. For our purposes, we prefer a more general concept that is equally applicable to continuous distributions, and that relates genetic distance inversely to effective gene flow. (Hybridization that produces offspring at an adaptive disadvantage is, of course, not fully effective. Through this mechanism, selection gradients may impress their features on flow differentiations.) However, since gene exchange can seldom be determined directly and is

usually inferred from trait clines, we turn our attention to the development of a systemic space. This, except for situations complicated by mass migrations, should be a reasonably close approximation to the space of genetic interaction—although necessarily there is a time lag between genetic processes and their cumulative effects.

Systemic distance *Syd* we define as the sums of average weighted trait differences taken over successive short geographical distances Δs. Between any two points $s_1 s_2$, and with Δs approaching zero, this may be expressed as an integral of the systemic function:

$$Syd^{s_1 s_2} \underset{\text{def}}{=} \int_{s_1}^{s_2} Syf \cdot ds.$$

Graphically, this is simply the area of a profile through the systemic topography, with the space loci s_1 and s_2 as bounding verticals. Systemic distances along any line may be measured planimetrically from a profile sketch. Results will be in slope-kilometer units, which are directly comparable to the systemic difference units ΔSy previously defined. If, between any two points, every trait cline continuously increases or decreases, the systemic distance will equal the systemic difference. With any trend reversals, the distance will be the larger. Over comparative distances, $\frac{\Delta Sy}{Syd}$ provides an intimation of genetic drift, although it also is sensitive to oscillations in the selection gradients, as well as to statistical techniques and mapping practices.

And now we re-examine the topography of the systemic function (Fig. 7*e*). Not only do the ridge lines bound natural subspecific groups; they also reveal much of the genetic interaction between them. Their elevations measure the sharpness of the distinctions between provinces, whereas their profile areas evaluate the systemic distance (and approximate the genetic distance) between the types. Saddles in the ridges indicate probable routes of intergroup gene flow. Isocline values of the basins are inversely related to the cohesiveness of the varieties. In fact, at any geographic locus, the value of the systemic function *Syf* is the measure of local geographic differentiation of the species. Its reciprocal $\frac{1}{Syf}$ is an index of geographic homogeneity.

Just as systemic space may be related to physical space by summing average trait differences over short distances, so (when adequate data are available) systemic time may be related to physical time by adding average changes in the heredity over short periods. Any number of variable character expressions or gene frequencies may be plotted in time profile and their slopes determined and averaged as a composite derivative, which we define as the temporal systemic function *Syft*. The measure of systemic time *Syt* is an integral of this variable:

$$Syt^{t_1 t_2} \underset{\text{def}}{=} \int_{t_1}^{t_2} Syft \cdot dt.$$

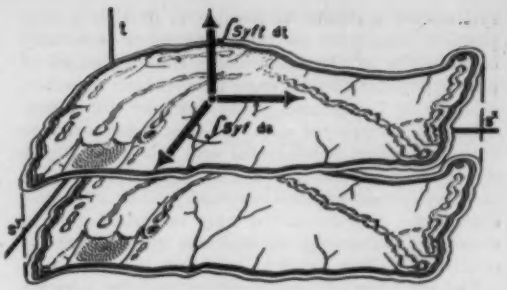

FIG. 8. By conceptualizing the systemic function as a plane of variable metric, the vertical dimension may be employed for the representation of systemic time.

Peak values indicate times of rapid evolutionary change and bound periods of longer enduring phases. (Scale values and time intervals for recording evolutionary change are still tentative. Haldane [8] suggests a *darwin* unit equal to an increase or decrease of size by a factor of e per million years—approximately 1/1000 per 1,000 years.)

To facilitate visualization, the spatial derivative has previously been presented as a three-dimensional topography, but it is equally valid to regard it as a non-Euclidian plane, related to a physical plane by the variable metric of "space density" provided by local values of the spatial systemic function. This makes available a third physical dimension, convenient for the representation of systemic time (Fig. 8). Additional analytic dimensions may be developed mathematically for problems involving nonassortative mating.

APPLICATIONS

Differential systematics, though originally developed for ordering well-studied, sexually reproducing species (especially man), is also applicable to other fields. Asexuals, obligatory parthenogenetic forms, and selfing hermaphrodites, lacking the species unification mechanism of gene exchange, would seem free to diversify in all directions. That such organisms still are found in only a limited number of fairly distinct types indicates either rigorous selection to well-defined ecological niches, or limited developmental possibilities, or both. The systemic functions of such forms may be developed by the same techniques employed for those of sexual species, but they require interpretation in terms of the differing genetics.

In one sense, every subspecific systematic is also a systematic of the geography and ecology, for in defining forms that *do* exist in any locality, it defines forms that *can* exist there. However, other indicators of environmental differentiation are more obvious. Ecologic balances tend to change abruptly through certain zones and periods, and to remain fairly constant over other areas and ages. Since the techniques of differential systematics may be extended to a synthesis of absolute and relative census figures for species, as well as to the averaging of any number of subspecific

systematics, it should be feasible to develop a composite of composites for the evaluation of uniformity or variation in the total biota. Differentiations in purely physical factors (e.g., temperature, elevation, rainfall, etc.) may also be evaluated by this methodology, and employed either in comparison with the biologic function or integrated with it to approximate the total environmental differentiation. However, in the development of such supercomposites, subjective evaluations play an increasingly important role in choosing from among the multiude of variables the relatively few it is practical to include in an analysis.

The subtleties of human culture and the intricate relationships of its elements pose problems for which, as yet, there appears to be no adequate mathematics. However, the quantification of even the grosser variables would permit the development of a systemic function which should better define the spatial and temporal structuring of culture fields and their patterns of interaction than do any of the current culture area and culture sequence classifications.

Dialects show analogies to subspecific phenomena. Like biologic varieties, they are involved in the uneasy dynamic equilibrium of their universes of interaction. In isolation they may "speciate" as distinct languages. This methodology would seem well suited to the ordering of the many variants of dialect geography.

It is not feasible at this time to foresee all possible applications of differential systematics. Essentially, it is a development in logic rather than a specialized technique. Consequently, it may be employed in the ordering of numerous realities exhibiting multiple variations through time and space. However, significant interpretation of differing systemic functions requires that individual attention be given to the processes involved in maintaining similarities and developing differences.

In addition to whatever value this formulation may have within various fields of study, it should open new avenues for the analysis of covariation and probable interaction between phenomena now departmentalized among separate, and often mutually incomprehensible, disciplines.

Differential systematics is a methodology for synthesizing multiple measurements, indices, and frequencies into a composite variable, the *systemic function*, which, for all loci, evaluates the average change with distance of a total reality. It is applicable to the analysis of any type, number, and combination of quantifiable traits, provided only they are related as to means of variation, diffusion, and interaction.

This technique does not completely exclude arbitrary elements from the ordering of complex phenomena, but it reduces them to a minimum and makes explicit much that is often implicit in the "feeling" of an authority. The necessity for assaying numerous continuous variables, which previously has proved a liability for the development of a clear systematic, is transformed into an asset in broadening the statistical base and minimizing effects of errors in data and in judgment.

Systemic space and systemic time are introduced as conceptual tools. Also, they serve to define an analytic manifold for future developments in space-time genetic calculus.

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Technical Papers

Contaminating Bacteria in Plant Tumor Tissues[1]

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In the course of investigations on plant tumors bacterial growth was noted when a tumor (P II) believed to be bacteria-free was grown on a peptone agar. None was observed when the tumor tissue was grown on a basal medium of mineral salts, cane sugar, and three vitamins (thiamine, pyridoxine, and nicotinic acid) used for the cultivation of the tumor tissues. In fact, this tumor tissue had been cultivated in this laboratory for several years with no evidence of bacterial contamination.

As a consequence of our observation, all the tumor tissues in our collection have been examined for sterility. None had shown bacterial growth on the medium used for growing the plant tumor tissue, although under cultivation for considerable periods of time. The plant tumors examined are shown in Table 1.

A portion of each of these tissues was mashed in a small amount of sterile distilled water, streaked on slopes of AC agar, and incubated at 36° C. The AC

[1] This work was supported in part by an American Cancer Society grant recommended by the National Research Council Committee on Growth.

TABLE 1

H 13	*Helianthus* tumor	Isolated from secondary sunflower tumor. July 1941. P. R. White
K I	" "	From a secondary tumor on an *in vitro* graft. Subcultured June 28, 1946. R. S. de Ropp.
K II	" "	Isolated from induced tumor. R. S. de Ropp.
K III	" "	Isolated from induced tumor. R. S. de Ropp.
P I	" "	Isolated from primary tumor 14/12/45. R. S. de Ropp.
P II	" "	Isolated from a different segment of same primary tumor as P I (14/12/45). R. S. de Ropp.
P III	" "	Isolated from primary tumor Feb. 1946. R. S. de Ropp.
V 60	*Vinca rosea* tumor	Isolated from heat-treated plants of *Vinca rosea*. Apr. 1943. P. R. White.
PN	*Parthenocissus* normal	G. Morel
PT	" tumor	" "
PA	" accustomised	" "
NT	*Nicotiana* tumor	" "

agar contained, per liter, 20 g proteose-peptone #3, 3 g yeast extract, 3 g malt extract, 5 g dextrose, 3 g beef extract, and 15 g Difco agar. All the tumor tissues showed the presence of bacteria except PN and PA.

The bacteria isolated from our cultures of plant tumor tissues are more fastidious in their nutritional requirements than *Agrobacterium tumefaciens*, which grows readily on the tissue culture medium at room temperature. The contaminating bacteria are gram-negative rods. They grow on AC agar but not on the tissue culture medium, and they grow more rapidly at 36° C than at room temperature. The bacteria isolated from each tumor were placed on disks from carrots that had been tested for ability to form tumors when inoculated with virulent *A. tumefaciens*. No tumors were produced.

The plant tumors were retested for bacteria by fragmenting bits on slopes of AC agar or on the medium supplemented with yeast extract described by Theis, Riker, and Allen (*1*). Again bacteria grew from all but PN and PA.

Thirteen different plant tumor tissues were obtained from another laboratory. Bacteria were demonstrated in four of these. This group of tumor tissues included duplicates of five of the strains of tumor tissues in our collection—namely, K I, NT, P I, P II and H 13. The P I, P II, and H 13 were sterile, the K I and NT were contaminated.

The contaminating bacteria would not seem to be causally associated with the tumorous condition of the tissue, since our P I, P II, and H 13 contained bacteria, whereas the same strains of tumors from another laboratory did not. However, plant tumor tissues that appear to be bacteria-free when grown on a medium suitable for the cultivation of tumor tissues may contain bacteria. This possibility must be considered and eliminated by the use of suitable test media and incubation temperatures when sterile plant tumor tissues are essential for the purposes of a particular investigation.

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The Isolation of *Histoplasma capsulatum* from Soil in an Unused Silo[1]

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The epidemiology of histoplasmosis in man is largely unknown. The fungus *Histoplasma capsulatum* has been isolated by Emmons from a variety of wild and domestic animals and from 6 of several hundred samples of soil collected from farms on which animals harboring the fungus had been trapped (*1, 3*). There is no direct evidence, however, that infected animals serve as vectors in the case of histoplasmosis in man or that contaminated soil is important in the epidemiology of the disease.

This report concerns the study of the possible source of the fungus (*H. capsulatum*) responsible for extensive pulmonary infections in 3 male members of a farm family living near Lowell, Ind. The father (A. E., age 53) and his two sons (E. E., age 20, and A. E., Jr., age 5), had been well until about Sept. 20, 1950, when they became ill at the same time with fever, chills, nonproductive cough, and weakness. X-rays of the chest revealed widespread noncalcified pulmonary infiltrates in all three. E. E. and A. E., Jr., were clinically ill for only 2 weeks, but the father failed to recover immediately and was admitted to Billings Hospital on Oct. 28, 1950. He had a stormy course but gradually improved and was discharged after 2 months' hospitalization. Sputum specimens were examined for the presence of fungi and acid-fast bacilli by culture and animal inoculation. Specimens collected on the fifth and twelfth hospital day yielded *H. capsulatum*, as did a bone marrow culture taken on the tenth hospital day. In all three, skin tests were positive to histoplasmin 1:100 dilution but negative to tuberculin (PPD 0.0001 mg) and coccidioidin 1:100. Sera from all three yielded highly positive complement fixation titers (A. E., 1:160; E. E., 1:320; and A. E., Jr., 1:160) in a test employing yeast phase histoplasma as antigen (*4*).

During the 2 months preceding their illness the two men had undertaken in addition to the usual farm chores (*a*) removal of "blow sand"—a fine shifting silt from driveways; (*b*) grinding feed composed of

[1] This investigation was supported in part by a research grant from the National Institutes of Health, USPHS, and by the Seymour Coman Fellowship Fund of the University of Chicago.

corncobs, oats, and straw in a closed shed; and (*c*) cleaning out a silo. The last activity was undertaken during the first week in September, 2–3 weeks before the onset of infection. It consisted of shoveling the silo floor clear of a foot of dried vegetable and sawdust material. The silo had been employed as an icehouse but had been unused for a number of years. A. E., Jr., sat in the truck into which his father and older brother shoveled the dust. Occasionally some would land on his head, and sometimes he threw handfuls in the air and back at the others.

It seemed important to survey the farm, and particularly the silo dust, as the most likely source of the fungus. The methods used for isolation of *H. capsulatum* were adapted after those suggested by Emmons (*1*). Briefly, these consisted of diluting the samples 5–10 times with normal saline in a cylindrical graduate. After thorough mixing the suspension was allowed to stand for an hour while the larger particles settled. One-ml portions of the supernatant were inoculated intraperitoneally into each of a group of 10 Swiss mice (CFW strain). Two to three mice from each group were then sacrificed at intervals of 10–30 days after inoculation, and their spleens and livers removed, ground in sterile sand, and cultured for the presence of fungi.

The culture media employed were corn-meal agar (*5*), Sabouraud's glucose agar (*5*), and blood agar plates which were enriched with glucose and cysteine and to which penicillin and streptomycin were added. The media were then streaked with the homogenized spleen and liver mixture, and all were incubated at room temperature. In addition, some duplicates of the blood agar plates were incubated at 37° C. The cultures were observed for 2 months. They were considered positive for *H. capsulatum* only after demonstration of the characteristic tuberculate chlamydospores.

On November 27, 1950, 70 samples of soil from about the farm buildings, yard sand, ground feed, and material from the silo were collected and pooled into 15 groups and examined for *H. capsulatum* as described above. The homogenized liver and spleens of mice inoculated with Groups 2 and 7 yielded *H. capsulatum* on culture with all three media. Both groups were from the silo. Group 2 consisted of one large sample from the floor of the silo. Group 7 was made up of 5 samples scraped from the walls of the silo. Examination of these 5 samples individually yielded histoplasma organisms from one.

Four months later, March 26, 1951, a second survey of the farm for the presence of the fungus was made. Sixty samples pooled into 6 groups were examined. Groups 2 and 6 containing material from the floor and from a ledge near the floor of the silo yielded *H. capsulatum* organisms.

It seems most probable that the father and two sons became infected from the inhalation of large quantities of infectious silo dust at the time the silo was cleaned. Monthly surveys of the silo environment are under way in an effort to learn more about the presence of this fungus in nature and the epidemiology of the disease in man and animals.

Addendum: Four additional monthly surveys have been made. Out of a total of 106 soil samples from the silo, 26 have yielded *H. capsulatum*.

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Differential Effects of Cerebellar Anterior Lobe Cortex and Fastigial Nuclei on Postural Tonus in the Cat[1]

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The influence of the anterior lobe (cortex and nuclei) of the cerebellum upon postural tonus has classically been considered a unitary one, its ablation causing marked hypertonicity of the antigravity extensors, and its presence partially inhibiting the tonus of these muscles even in the decerebrate animal. Electrical stimulation of the medial part of the anterior lobe cortex itself, or its nuclei of projection, the fastigial nuclei, inhibits extensor and facilitates flexor tonus in the normal or decerebrate animal, the inhibition being followed, upon cessation of the stimulus, by a powerful extensor rebound which exceeds for a length of time the tonus present before the stimulus. When ablation or stimulus is confined to one side, the extensor release or its inhibition has been considered to be primarily on the ipsilateral side, although reciprocal effects have been noted in the contralateral limb. These effects, at least in the cat and the dog, are more pronounced in the fore than in the hind legs.

Since electrical stimulation of the medial anterior lobe cortex and of the fastigial nuclei give similar inhibitory and rebound phenomena, it has been assumed that these structures similarly affect tonus mechanisms. That such an assumption is erroneous is indicated by the following acute experiments on decerebrate cats. Fig. 1 shows schematically the relative position of the two forelegs following decerebration (*A*), the lesions indicated by crosshatch.

When the cortex only of the medial anterior lobe is removed by aspiration on one side (*RMC*), the response of the forelegs is the classical one—i.e., augmentation in extensor and decrease in flexor tonus in the leg of the same side (Fig. 1, *B*). Moreover the effect is reciprocal in that the opposite distribution

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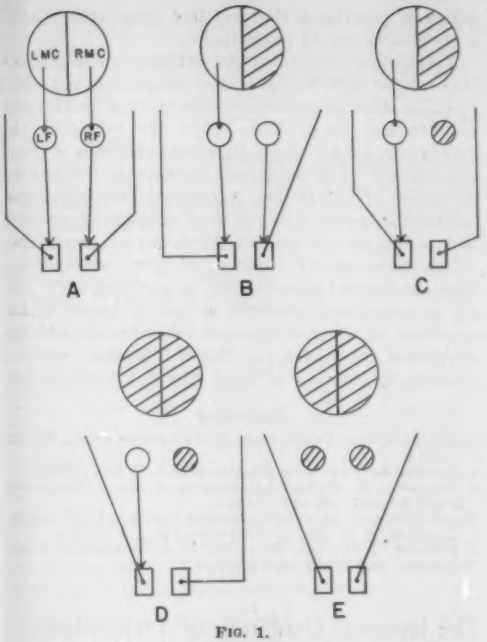

FIG. 1.

of tonus is present in the leg of the contralateral side. Subsequent removal of the fastigial nucleus (*RF*) on the side of previous cortical ablation gives an immediate and clear-cut reversal of the cortical picture (Fig. 1, *C*).

The effects following removal of the remaining cortex of the anterior lobe, and its fastigial nucleus are illustrated in *D* and *E*. The bilateral augmentation of extensor tone seen in *E* is identical with that following bilateral destruction of cortex only.

These effects are related only to median or vermian cortex of the anterior lobe and to the fastigial nuclei. The lateral or hemispheric anterior lobe cortex and its nuclei of projection, the so-called interpositus nuclei, are relatively inoperative on postural tone under these conditions. Their stimulation, however, gives ipsilateral, moderate extension and wrist supination, followed by a rebound of opposite direction. Stimulation of the medial area confirms the usual picture previously described, involving contralateral as well as ipsilateral forelegs in a reciprocal manner.

The general conclusions from this work are as follows:

1) Imposed upon a background of decerebrate rigidity, one half of the medial cortex of the anterior lobe, or its fastigial nucleus, always influences postural tone in the forelegs in a reciprocal manner. An increase in extensor tonus in one leg is accompanied by extensor decrease in the contralateral leg. Flexor tone, although less marked, follows in each leg reciprocally.

2) The effect of removal of this cortex is reversed by removal of its fastigial nucleus. This nuclear picture has hitherto been unrecognized, and makes necessary considerable alteration in the concept of cerebellar function.

3) These results, obtained in acute preparations, have been completely confirmed in chronic animals with unilateral cerebellar lesions produced 3 weeks previous to decerebration.

4) The picture following unilateral cortical removal is thus the same as that of extensor rebound following electrical stimulation of cortex or nucleus. The picture following subsequent unilateral nuclear removal is similar to that occurring during the stimulus of cortex or nucleus (i.e., extensor inhibition accompanied by flexion).

5) The release of this nuclear effect following cortical removal indicates an important afferent supply, other than from the anterior lobe cortex, which allows independent function of the fastigial nucleus.

6) Additional acute experiments indicate that the postural effects described above are intact following unilateral and bilateral destruction of the labyrinths, of the dorsal roots of the first three cervical nerves, after hemisection and transection of the thoracic spinal cord, and after previous removal of all parts of the cerebellum except the anterior lobe and the fastigial nuclei.

7) The distribution of tone in the forelegs is similar following bilateral destruction of cortex and nuclei to that following bilateral destruction of cortex alone. The opposite postural effects of cortex and fastigial nucleus are apparent after unilateral lesions only, and would appear to be a manifestation of an imbalance in the reciprocal distribution of tone, dependent upon the unilaterality of the lesions, and centered at a spinal level.

The Pharmacologic Analysis of Intestinal Stimulants[1]

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A recent report from this laboratory dealt with the inability of even high concentrations of atropine to interfere with the stimulating action of nicotine on the isolated intestine of the rabbit (*1*). Although this observation may be found in the literature (*2*), it is quite evident that the rabbit's intestine has been used for testing the ability of atropine to antagonize stimulating actions of drugs on this preparation without a knowledge of the above information. The widely accepted concept that the stimulating action of nicotine on the intestine is antagonized by atropine appears true in reference to other animals. This has been con-

[1] This work was supported in part by a grant from the Committee on Research of the Council on Pharmacy and Chemistry of the American Medical Association.

firmed on intestinal strips obtained from guinea pigs, rats, dogs, and cats. On the basis of these observations a revaluation of certain data in the literature concerning the sites of action of several intestinal stimulants is needed.

Evidence that a substance stimulates the intestine of the rabbit and that this action is "atropine-fast" indicates only that the substance is not "muscarinic" and does not differentiate between "musculotropic" and "nicotinic" modes of action. On the other hand, a stimulating action on the guinea pig's intestine which is inhibited by atropine indicates musculotropic action but does not distinguish between actions which are either muscarinic or nicotinic.

For examples of different types of intestinal stimulants we have reinvestigated 3 compounds, whose sites of actions on the intestine do not appear sufficiently clear from the data available. Furfuryltrimethylammonium iodide (Furmethide) was reported (*3*) to have nicotinic action on the blood pressure of atropinized animals and to have a stimulant action on the rabbit's intestine which could be inhibited by atropine. Piperidine has been reported to stimulate the intestine (*4*). Von Euler considered the actions of piperidine similar to, but less potent than, those of nicotine. On the rabbit's intestine atropine did not inhibit the action of piperidine. Lockett (*5*) described the action of piperidine on the guinea pig intestine as muscarinic, based upon the ability of atropine to interfere with its stimulating action on this tissue. A recent abstract (*6*) indicated that a purified extract of Veratrum Viride (Veriloid®) increased the tone of the isolated rabbit's intestine. This action was not prevented by previous treatment with atropine.

The actions of Furmethide, piperidine, and veratridine[2] were compared with the actions of acetylcholine and nicotine on the isolated, atropinized intestines of rabbits and guinea pigs in order to determine the classification of these stimulants of the intestine. The data are summarized in Table 1.

TABLE 1

ACTION OF INTESTINAL STIMULANTS IN THE PRESENCE OF ATROPINE (1: 1,000,000)

Drug	Conc.	Intestine of	
		Rabbit	Guinea pig
Acetylcholine	$1:10^5$	No action	No action
Nicotine	$1:10^6$	Stimulates	"
Furmethide	$1:10^5$	No action	"
Piperidine	$2:10^4$	Stimulates	"
Veratridine	$1:10^6$	"	Stimulates

Since Furmethide is unable to stimulate the atropinized intestine of either the rabbit or the guinea pig, it is justifiable to call its effect muscarinic. Piperidine then appears as a nicotinic agent. Further evidence favoring a nicotinelike action for piperidine is that large amounts of nicotine prevent the stimulating action of piperidine (but not that stimulation due to acetylcholine nor to Furmethide).

Veratridine stimulates the intestine in a manner that can be classified as neither muscarinic nor nicotinic. Its stimulating action is not blocked by atropine on intestinal strips from either the rabbit or the guinea pig. Furthermore, high concentrations of nicotine which produce ganglionic blockade do not prevent the action of veratridine. Amounts of D-tubocurarine sufficient to prevent the action of stimulating amounts of nicotine, do not prevent the action of veratridine.

The mechanism of action of an agent which stimulates the isolated intestine can be analyzed quite simply as muscarinic, nicotinic, or musculotropic by the expedient of using atropinized intestines of both the rabbit and the guinea pig. Results obtained with the intestine of only one of these species are misleading.

[2] A pure sample of veratridine was obtained through the kindness of Otto Krayer, of the Harvard Medical School.

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The Bacterial Oxidation of Tryptophan: A Study in Comparative Biochemistry[1]

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As discovered independently by several workers (*1–3*), the analysis of adaptive patterns is of much value in the study of microbial metabolism. This technique (sometimes referred to as "simultaneous adaptation" or as "successive adaptation") is essentially an extension and refinement of the technique of kinetic analysis, and may be used to study the course of any microbial metabolic process that is under adaptive enzymatic control (*4*).

One of the specific problems that has been investigated primarily by the analysis of adaptive patterns is the pathway for the complete oxidation of tryptophan by bacteria belonging to the *Pseudomonas* group. Suda, Hayaishi, and Oda (*2*) found that an unidentified *Pseudomonas* sp.[3] adapted to oxidize tryptophan was also fully adapted to oxidize kynurenine, anthranilic acid, and catechol, but not to

[1] This work was supported by grants-in-aid from the Rockefeller Foundation, and from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council. We are indebted to R. E. Kallio, W. C. Evans, D. Bonner, T. Sakan, and the Research Division of Merck & Co., Inc., for gifts of chemicals, and to S. H. Hutner for the provision of biological material. In addition, we wish to express our thanks to Martha Tsuchida for help with many experiments.

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[3] This organism has been subsequently identified by us as a typical member of the *P. fluorescens* species group.

TABLE 1

ADAPTIVE PATTERNS SHOWN BY 29 STRAINS BELONGING TO THE *Pseudomonas* GROUP AFTER GROWTH IN THE PRESENCE OF DL-TRYPTOPHAN

Strains	Cells adapted (+) or unadapted (−) to oxidize				
	L-tryptophan	D-tryptophan	L-kynurenine	Anthranilic acid	Kynurenic acid
P. fluorescens (strain of Suda, Hayaishi, and Oda)	+	−	+	+	−
Pseudomonas sp. (strain of Stanier and Tsuchida)	+	+	+	−	+
Pseudomonas spp., 20 additional strains (10 belonging to the *P. fluorescens* group)	+	±(1) or −	+	+ or ±(2)	−
Pseudomonas spp., 5 additional strains (none belonging to the *P. fluorescens* group)	+	+	+	−	+
Pseudomonas sp., strain Tr-14	+	−	+	−	−
P. fluorescens, strain Tr-13	+	−	−	−	−

(1) A few strains of this group can oxidize D-tryptophan at a low rate (20% or less of the rate at which they oxidize L-tryptophan).

(2) Two strains of this group show greatly impaired ability to oxidize anthranilic acid, which accumulates when they are supplied with tryptophan or kynurenine.

oxidize other, theoretically possible intermediates. The organism attacked only the L-isomer of tryptophan. Accordingly, the following pathway was proposed for the initial steps in the oxidation:

L-tryptophan → L-kynurenine → anthranilic acid → catechol → ?

Independently, Stanier and Tsuchida (*5*) conducted a similar investigation upon another unidentified *Pseudomonas* sp. This organism attacked both isomers of tryptophan, and tryptophan-adapted cells were also adapted to oxidize kynurenine and kynurenic acid, but none of a wide variety of other compounds tested, including anthranilic acid. The observed adaptive patterns implied the existence of distinct mechanisms for attack on the two stereoisomers of tryptophan and kynurenine, and hence the following initial steps were postulated:

L-tryptophan → L-kynurenine → kynurenic acid → ?

D-tryptophan → D-kynurenine → kynurenic acid → ?

In the ensuing discussion, the oxidation of tryptophan through anthranilic acid and catechol will be referred to as *the aromatic pathway*, and that through kynurenic acid as *the quinoline pathway*.

The marked differences in dissimilatory patterns of closely related bacteria revealed by these reports made a more extensive investigation desirable, and this we have recently undertaken. A large collection of tryptophan-oxidizing pseudomonads has been subjected to systematic comparative study. Adaptive patterns were determined by growing each strain on a medium containing DL-tryptophan as the energy source, harvesting the cells in phosphate buffer, and testing manometrically their ability to oxidize the following 5 compounds: D-tryptophan, L-tryptophan, L-kynurenine, anthranilic acid, and kynurenic acid. Limiting amounts of the substrates (2 μM) were used in the manometric tests to permit detection of any anomalies in total oxygen consumption. More extensive confirmatory tests, employing a wider range of compounds, were subsequently conducted with a few representative strains and gave results in accord with expectations. Table 1 summarizes the general findings, which provide confirmation of the existence of the two pathways diverging from kynurenine that had been proposed earlier by Suda, Hayaishi, and Oda and by Stanier and Tsuchida. Of 27 new strains tested, 20 followed the aromatic pathway and 5 the quinoline pathway. The difference between the two biochemical groups with respect to the oxidation of D-tryptophan has also been confirmed: every strain using the quinoline pathway oxidizes the D-isomer at a high rate, whereas strains using the aromatic pathway either do not attack it at all, or oxidize it at a rate that is low in comparison to the rate of oxidation of the L-isomer.

Two strains that decompose tryptophan through the aromatic pathway are characterized by an interesting metabolic abnormality, which proivdes additional evidence for the existence of this pathway. Their ability to oxidize anthranilic acid is severely impaired, and consequently a substantial accumulation of this compound occurs when they are fed either tryptophan or kynurenine. The severity of the metabolic block between anthranilic acid and catechol in these two strains varies somewhat, depending on the conditions of prior cultivation and the age of the cells, but in some experiments accumulations of anthranilic acid approaching 90% of the theoretical yield on a molar basis have been obtained following the addition of tryptophan or kynurenine to cell suspensions.

Two of the 29 strains tested displayed adaptive patterns after growth on tryptophan that were incompatible with an oxidation through either the aromatic or the quinoline pathway, and in both cases the total oxygen uptake per mole of tryptophan de-

composed was exceptionally low, indicating an early and absolute metabolic block. The first of these strains, Tr-14, could oxidize only L-tryptophan and L-kynurenine of the substrates tested (Table 1). Spectrophotometric analysis of the supernatant liquid from a reaction vessel in which tryptophan had undergone oxidation suggested the accumulation of a mixture of anthranilic and kynurenic acids, an inference subsequently confirmed by isolation and characterization of the two compounds in an experiment conducted on a larger scale. The oxidation of either tryptophan or kynurenine by Tr-14 always results in the formation of these acids, the sum of the amounts of the two products being equal on a molar basis to the amount of substrate decomposed. Tr-14 is the only strain so far investigated in which a "mixed" dissimilation, involving the production of both benzene and quinoline derivatives, has been shown to occur; and its metabolism of tryptophan is so defective that the result could be described better as a "branched cul-de-sac" than as a "mixed pathway."

The second strain showing anomalous adaptive patterns (strain Tr-13) could metabolize only L-tryptophan of the compounds tested (Table 1); spectrophotometric analysis, followed by isolation and characterization of the product, showed that it converted tryptophan quantitatively to indole. We have not further investigated the mechanism of oxidation in this exceptional strain, which belongs to the *Pseudomonas fluorescens* species group. Ten other fluorescent pseudomonads tested all dissimilated tryptophan by the aromatic pathway.

Guided by these findings with intact cells, we then turned our attention to the enzymatic aspects of the problem. One previous report on an enzyme operative in tryptophan oxidation by the aromatic pathway had been made by Hayaishi and Hashimoto (*6*), who worked with the strain of *P. fluorescens* studied by Suda *et al.* (*2*). By extraction of acetone-dried cells grown at the expense of anthranilic acid, Hayaishi and Hashimoto obtained a catechol-oxidizing enzyme which they named pyrocatechase. After extensive purification, pyrocatechase was found to catalyze an oxidation of catechol with an uptake of 2 atoms of oxygen and with the formation of an acid which appeared to be identical with *cis-cis*-muconic acid, on the basis of melting point and elementary analysis. A crude enzyme system of very similar properties was isolated independently by Stanier *et al.* (*7*) from dried cells of another strain of *P. fluorescens*, grown on phenol, benzoic acid, or mandelic acid. It was shown to catalyze a conversion of catechol, again with an oxygen uptake of 2 atoms, to β-ketoadipic acid. Since it appeared improbable that two distinct enzymes catalyzing an opening of the catechol ring would be formed by *P. fluorescens*, we decided to reinvestigate catechol oxidation, using extracts from tryptophan-grown cells. A crude cell-free system was readily obtained from vacuum-dried cells, and was found to catalyze the reaction described by Stanier *et al.*—namely, an oxidation of catechol to β-ketoadipic acid. This indicated that the enzymatic degradation of catechol might involve an initial oxidative and a subsequent nonoxidative step:

$$\text{catechol} + O_2 \xrightarrow[\text{(pyrocatechase)}]{} \textit{cis-cis}\text{-muconic acid} \qquad (1)$$

$$\textit{cis-cis}\text{-muconic acid} + H_2O \xrightarrow[\text{(unknown enzyme)}]{} \beta\text{-ketoadipic acid} \qquad (2)$$

$$\text{catechol} + O_2 + H_2O \xrightarrow[\text{(crude extracts)}]{} \beta\text{-ketoadipic acid} \qquad (1) + (2)$$

It was easy to test this hypothesis, since a small amount of the alleged *cis-cis*-muconic acid, isolated by Hayaishi and Hashimoto after the action of pyrocatechase on catechol, was still available. An attempt to demonstrate the conversion of this material to β-ketoadipic acid by our crude catechol-oxidizing extract gave *completely negative results*. The work of others has recently clarified this very puzzling situation. Elvidge *et al.* (*8*) have discovered the third geometrical isomer of muconic acid, which possesses the *cis-trans* configuration, and have further shown that the *cis-cis* isomer is unstable in aqueous solution, undergoing ready isomerization to the *cis-trans* form, from which it cannot be readily distinguished, since the physical and chemical properties of the two substances (including their melting points) are very similar. It is thus probable that most earlier chemical data reported for the *cis-cis* isomer were obtained with the *cis-trans* isomer, or with a mixture of the two. Following these chemical studies, Evans and Smith (*9*) examined the biological behavior of the 3 isomers of muconic acid, and found that the *cis-cis* isomer is an intermediate in the bacterial degradation of benzoic acid and phenol to β-ketoadipic acid, whereas the *cis-trans* and *trans-trans* isomers are inactive. Tests made by us on samples of the *cis-cis* and *cis-trans*-muconic acids have shown that our crude catechol-oxidizing enzyme system from tryptophan-grown cells smoothly converts the former isomer in a nonoxidative reaction to β-ketoadipic acid, but does not attack the latter isomer, thus fully confirming the conclusions of Evans and Smith. In the light of these discoveries, it is now evident that Hayaishi and Hashimoto had purified pyrocatechase to the point at which the second, nonoxidative step was eliminated; but that the *cis-cis* muconic acid produced enzymatically underwent isomerization during the the isolation procedure, which explains its inactivity when subsequently tested with the crude enzyme by us.

Although extracts from tryptophan-adapted, vacuum-dried cells of strains that follow the aromatic pathway show strong activity against catechol, they are inactive against tryptophan itself. In a search for better methods of making cell-free preparations, we found that the technique of grinding wet cells with alumina, discovered by McIlwain (*10*), yielded extracts containing many additional enzymes. Fresh, concentrated extracts prepared in this manner from tryptophan-grown cells catalyze an oxidation of tryptophan which results in the consumption of 8 atoms of oxygen per mole of substrate and yields β-keto-

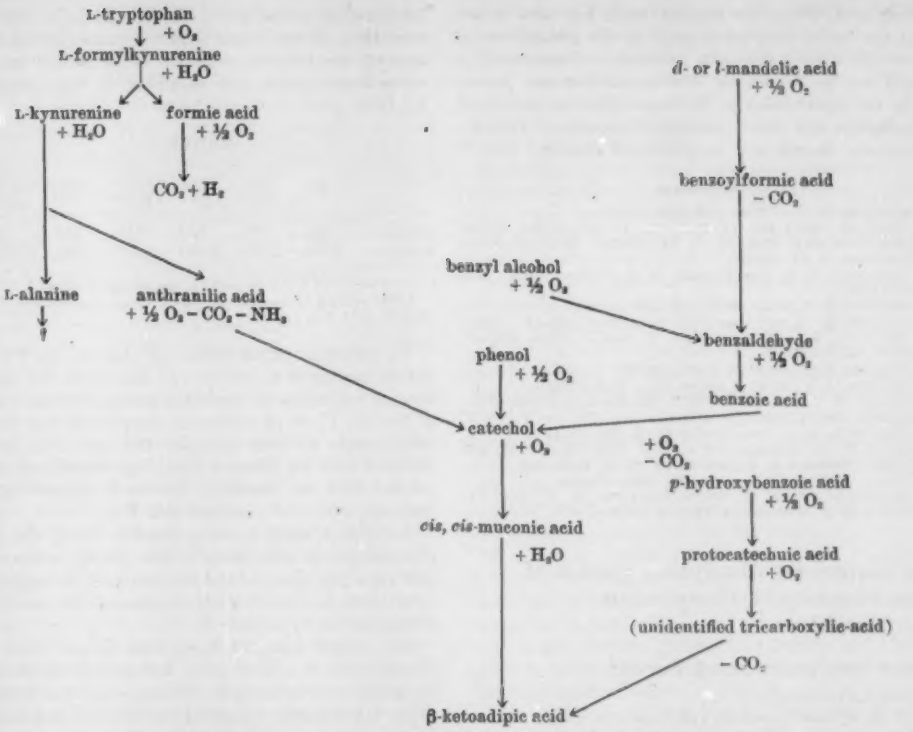

FIG. 1. A comprehensive diagram of the known bacterial metabolic pathways that converge with the formation of β-ketoadipic acid as an intermediary metabolite. Other divergent pathways from tryptophan are not shown.

adipic acid as one of the end products, demonstrating that a complete destruction of the indole nucleus must have taken place. Aging or simple dilution of such extracts results in the elimination of several oxidative steps, the total oxygen uptake per mole of tryptophan falling to 5, 3, or even 2 atoms. The oxidation of tryptophan catalyzed by such aged or diluted preparations involves the steps discovered recently by Knox and Mehler (*11*) for the dissimilation of tryptophan to kynurenine via formyl-kynurenine in mammalian liver extracts. With the bacterial preparations, however, kynurenine does not accumulate, since a powerful kynureninase is also present, which causes a nonoxidative cleavage of L-kynurenine to anthranilic acid and L-alanine. This enzyme, which is the only one that we have so far studied in detail, coincides in all essential properties with the mammalian kynureninase recently described by Wiss (*12*) and by Braunshstein, Goryachenkova, and Paskhina (*13*).

The work reported here permits the construction of a broad conceptual scheme that describes the oxidation of tryptophan by many bacteria, and that links up one of the possible alternate pathways for the metabolism of tryptophan with a series of other primary oxidative sequences previously known to occur in bacteria. It is now evident that the initial attack on tryptophan most commonly involves elimination of the α carbon atom of the indole nucleus, resulting in the formation of kynurenine as an intermediary metabolite. Below kynurenine, alternate metabolic pathways are open; some bacteria degrade this compound to kynurenic acid (presumably by a specific deamination or transamination, followed by secondary ring closure), whereas others split it to alanine and anthranilic acid through the action of kynureninase. At present we do not know the nature of the later intermediates formed on the pathway through kynurenic acid; enzymatic studies have not yet been attempted, and although many benzene derivatives have been tested by analysis of the adaptive patterns of tryptophan-grown cells, the results have been uniformly negative. The outcome of these analyses suggests that the benzene moiety of the quinoline nucleus in kynurenic acid may be first destroyed, with resultant eventual oxidation via pyridine derivatives. Several of the later steps on the aromatic pathway are now firmly established. This pathway merges, near the point of final ring rupture, with oxidations of nonnitrogenous primary aromatic substrates, such as mandelic acid, phenol, and *p*-hydroxybenzoic acid (*4*); as shown in Fig. 1, the common central intermediary metabolite for all these oxidations is β-keto-

adipic acid. Since the present work has also shown that the initial enzymatic steps in the breakdown of tryptophan are common to bacteria and mammals, it would not be surprising if β-ketoadipic acid proves to be an intermediate in the mammalian oxidation of tryptophan and other aromatic compounds. Full experimental details will be published shortly.

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The Ultraviolet Absorption Spectra of Some Heterocyclic Phosphorous Compounds[1]

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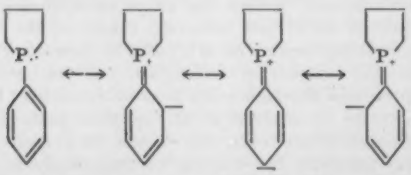
It is becoming increasingly evident that the phenomenon of resonance is not an exclusive property of any group of atoms in the periodic chart. For the ε max value of 1-phenylcyclotetramethylenephosphine (I), its 2-methyl (II), or its 2,5-dimethyl (III) homologues can best be explained in either of two ways; both explanations involve the concept of resonance.

As 1-phenylcyclotetramethylenephosphine (I) is an isologue of a substituted aniline, an analogous postulate can be made:



This hypothesis (A) should predict the following: (*a*) The ε max should have a lower value if the compound is measured in hydrochloric acid; (*b*) the 2-methyl homogogue (II) should not have the phenyl group completely planar with the phosphorous group, and hence some interference with the resonance should be manifested by lower ε max values; (*c*) the 2,5-dimethyl homologue (III) should have very little resonance, if any, other than the usual Kekule resonance of the benzene ring. No effect should be noted when hydrochloric acid is added to this compound. All these predictions are borne out (Table 1).[3]

TABLE 1

	I*	I in HCl†	II*	II in HCl†	III*	III in HCl†
λ (mμ)	250	251	249	247	252	No
ε max	6,500	2,830	4,050	3,020	865	Change

* I and II as 2 mg % and III as 10 mg % in 95% ethanol.
† For second measurement, one drop of concentrated hydrochloric acid was added.

An alternate explanation (B) for the high ε max values compared to aniline (*1*) may lie in the extreme ease of oxidation of these compounds by the oxygen of the air. These phosphorous compounds may tend to exist partly as free radicals. The lone electron can resonate with the benzene ring. This hypothesis should predict that on standing the ε max should rapidly decrease. Observations show this, too.

Additional work is being done to see if the phosphorous group will direct a new group to the *ortho* and *para* positions on the benzene ring in support of hypothesis A, and if these compounds are associated in support of hypothesis B.

The values reported here were taken from compounds kept in sealed tubes, but opened occasionally for withdrawal of samples. It is possible that measurements taken under completely anhydrous and oxygen-free conditions would show that the ε max values for these compounds would be much higher.

Details of preparation will be published elsewhere.

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[1] A Frederick Gardner Cottrell grant from the Research Corporation is gratefully acknowledged.

[3] Taken from the M. S. thesis of Robert J. Horvat.

The Effect of Aureomycin and Vitamins on the Growth Rate of Chicks

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Following the discovery by Stokstad and Jukes (*1*) that the feeding of aureomycin had a stimulating effect on the growth of the chick, several reports have appeared on the effects of feeding antibiotics to chicks and to various other animals. It was found that with animals other than ruminants the inclusion of an antibiotic in the feed almost invariably resulted in a marked increase in the rate of growth. There are, however, reports of instances where the addition of antibiotics to a ration had no effect on the growth rate. Speer *et al.* (*2*), for example, reported an experiment in which the addition of aureomycin to a ration fed to young pigs had no effect on the growth rate. The

TABLE 1

COMPOSITION OF BASAL RATION

Ingredient	Lb/100 lb	Ingredient	G/100 lb
Ground yellow corn	78.34	Manganese sulfate	10.0
Casein	12.0	Ferric citrate	5.0
Gelatin	4.8	Copper sulfate	0.5
Bone meal	2.0	Riboflavin	.16
Limestone	1.0	Nicotinic acid	.8
Iodized salt	0.5	Calcium pantothenate	.5
Feeding oil (3,000 A, 400 D)	.25	Pyridoxine hydrochloride	0.16
Choline chloride (25%)	.44	*Para*-aminobenzoic acid	1.6
Arginine hydrochloride	.05	Folic acid	0.02
DL-methionine	.60	Menadione	.02
DL-tryptophan	0.02*	Vitamin B_{12}	0.0015

* In Expt 3, 0.01% DL-tryptophan was added.

authors explained the lack of response to the aureomycin by the "disease level" theory. Scott and Glista (*3*), working with chicks, noted only a slight insignificant response to aureomycin for the first few weeks with *ad lib* feeding, and no response when feed intake was limited. The chicks in this experiment "originated from a well fed group of breeding hens and hence were not depleted of APF reserves." Oleson, Hutchings, and Whitehill (*4*) found that APF-depleted chicks showed no response to aureomycin in the absence of vitamin B_{12} in the diet, although there was a marked response to the antibiotic when vitamin B_{12} was present in suboptimal or optimal amounts. There appeared to be a mutual sparing action between aureomycin and vitamin B_{12}.

TABLE 2

AVERAGE WEIGHTS OF NEW HAMPSHIRE COCKERELS FED EXPERIMENTAL RATIONS

Expt No.	Ration*	No. chicks	Average wt (g) at
			28 days
1	Basal	21	377
	Basal plus aureomycin†	19	377
			30 days
2	Basal without folic acid	18	308
	Basal " " " plus aureomycin‡	18	410
			21 days
3¶	Basal	18	243
	Basal plus aureomycin‖	15	247
	Basal without riboflavin	18	211
	Basal " " plus aureomycin‖	17	251
	Basal without nicotinic acid	16	211
	Basal " " " plus aureomycin‖	15	243
	Basal without folic acid	18	211
	Basal " " " plus aureomycin‖	20	234

* Composition of basal ration is given in Table 1.
† 0.3% Lederle APF supplement containing aureomycin.
‡ Crystalline aureomycin HCl, 16.66 mg/lb.
¶ Minimum significant difference at 5% level, 20; at 1% level, 27.
‖ 0.25% Lederle APF supplement "aurofac."

Experiments conducted in this laboratory have shown considerable differences in the response of chicks to aureomycin, apparently as a result of differences in the composition of the diet fed to the breeders and/or the chicks.

In feeding a chick ration (Table 1) containing vitamins at levels above those recommended by the N.R.C., it was noted that the addition of aureomycin resulted in no increase in the rate of growth of chicks fed the experimental ration (Expt 1, Table 2).

In order to determine the effect of aureomycin on the growth rate of chicks fed a ration deficient in one of the vitamins, a test was set up in which a folic acid–deficient ration was fed with and without crystalline aureomycin (Table 2). At 4 weeks of age the chicks on the folic acid–deficient ration averaged only 308 g in weight and were poorly feathered. The birds receiving aureomycin, in spite of a suboptimal amount of folic acid in the diet, averaged 410 g and were well feathered (Expt 2, Table 2). It would therefore appear that the feeding of aureomycin to chicks lowered their dietary requirement for folic acid.

In a further experiment (Expt 3, Table 2), rations that were deficient in riboflavin, nicotinic acid, and folic acid, respectively, were fed with and without crystalline aureomycin. It will be seen from the data that the growth rate of the chicks fed the basal ration was not stimulated by the addition of aureomycin. However, when riboflavin, nicotinic acid, or folic acid was omitted from the basal ration, there was a significant decrease in the rate of growth. The addition of aureomycin to these vitamin-deficient rations stimulated the growth rate in each case to the extent that the chicks fed the vitamin-deficient rations containing aureomycin attained weights similar to those fed the complete basal ration.

It would appear from the data of the above experiments that dietary levels of nicotinic acid, folic acid, or riboflavin that are suboptimal for maximum growth rate of the chick under normal conditions may be adequate when aureomycin is fed. It is quite probable that the effect of aureomycin, in lowering the dietary requirements for certain vitamins, is brought about through a reduction in the numbers of intestinal microflora which might compete with the host for members of the vitamin B complex and/or by permitting the proliferation of microorganisms which synthesize these vitamins. The feeding of aureomycin would thus make available to the chick a larger proportion of the vitamins supplied by the diet and/or increase the amounts of vitamins available as a result of favorable microbiosynthesis.

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Comments and Communications

How Does the Ivy Grow?

AT COMMENCEMENTS and "homecomings," when college students and visiting grads return to their ivy-covered colleges, the question is occasionally asked: "How does the ivy manage to cover buildings with uniform coats of bright greenery?" To answer this question, I measured the rate of growth of a single shoot of ivy growing on the east window of a Harvard house. The following data were recorded between June 8, 1950, and June 12, 1950. Measurements were made with a millimeter rule at 12-hr intervals.

Date	Shoot length (cm)	Growth (cm)
6/8	2.0	—
6/9	6.5	4.5
6/9	10.5	4.0
6/10	13.8	3.3
6/10 (rain)	18.0	4.2
6/11	21.5	3.5
6/11	23.0	1.5
6/12	25.0	2.0

Thus, for a typical 12-hr period, the rate averaged 0.375 cm/hr during the first 2 days of recorded growth and approximately half this rate during the last 2 days of recorded growth. These incidental observations may help to explain the phenomenal rate at which ivy covers buildings. At an approximate rate of 0.5 mm/min, one can practically see it grow.

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Training Leaders in Science and Religion

Two recent studies have designated liberal arts colleges as the most fruitful source of American scientists (*1*). This position of leadership can hardly be ascribed to the research interests of these institutions, for only 13 liberal arts colleges of the first 50 institutions listed by Knapp and Goodrich published any research in the *Journal of the American Chemical Society* during the 15-year period 1927–41 (*2*). The colleges represented in this leading research journal totaled only 217 pages in the decade and a half.

A more significant relation is to be found in the high percentage of church-related colleges among the institutions leading in the training of scientists. Seven of the first 10 on the list of Knapp and Goodrich are church-related, and 24 of the 50 are listed by *The College Blue Book* (*3*) as church-controlled. Ten of the 14 leading colleges in Lewis' list (Table 4) are church-related.

Denominational colleges have long been recognized as the most fruitful training ground for religious leaders. Their position of distinction in the training of leaders in science is only now coming to light through these studies on the origins of American scientists. For those who are baffled by this unique relationship of religion and science a statement credited to the late Max Planck may provide food for thought (*4*): "Religion and natural science do not exclude each other, as many contemporaries of ours would believe or fear; they mutually supplement and condition each other."

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Gantt to the Rescue!

DEAR MR. MONEYED MAN:

I deeply sympathize with your state of mind (*Science*, **113**, 333 [1951]), although I do not agree with you as to the facts. I am ready to spring to your relief without an instant's hesitation. I have the secret whereby your name can go down in fame, and the next generation will not even take the trouble to discriminate between you and Faraday and Keats.

Before I state my plan for relieving you of both your fameless state and your money, I beg the opportunity to correct some of your facts. It is true that a few European streets may be named for Helmholtz, Curie, and Pavlov, but what about the universities named for the moneyed men? Who was Johns Hopkins? Who was Duke? Who was Phipps? Who was Rockefeller? Who was Carnegie? Who was or is Du Pont? Who was Vanderbilt? Who was Smith? (Not the man with the long whiskers and the cough?) Who was Vassar? ("Brewer and Merchant.") Not one of them a scientist, but all suppliers of names and lucre to needy institutes. And who were Wells (Wells, Fargo), Bowdoin, Morgan (J. P.), Eastman, Ford, Diamond Jim Brady, etc. etc., *ad infinitum*?

In view of the stiff competition your colleagues have given you, naturally you feel discouraged. But wait a moment, do not become downhearted—the offer I am about to make you will quicken your step, make your heart throb, your face flush, and shake you in a way that was never done for poor, ailing, dreamy, drugstore Keats, Shakespeare, Galileo, or Newton. I have an immediate plan guaranteed to give you the fame that your brethren, mentioned above, have received, I am sure that they were once in your position, casting about frantically for some way to outdo the scientists—and they certainly have accomplished it.

Now, our laboratory is very much in need of a name like yours with big money. We will take part of the

money—if there is enough—to buy a marble tablet, a portrait, a bust, an autographed photograph, an album bound in gold of some of the letters you have dictated, plus your name in big letters over the door and on every article, reprint, letterhead, and word of wisdom that issues from this laboratory. Wherever the human being, his conditional reflexes, neuroses, psychoses, are being discussed, your name will inevitably be tagged on.

This offer has a certain time limit. As the advertisers say, we cannot guarantee acceptance of your money unless you act at once. Other donors are on the alert, they have been animated by the same fear that stirs you (they get up early in the morning looking for universities to endow), and I cannot urge you too strongly to act immediately, as we will be forced to take the first and biggest donor that accepts this offer to go down in fame. I am already making plans to replace the present wooden sign with an appropriate marble slab. Owing to the great demand, there are not enough good laboratories and universities to go around. In order not to be disappointed, please act quickly. Your offer, to be considered, must not be signed anonymously.

Assuring you of our speedy cooperation in your plight,

Faithfully yours,
W. Horsley Gantt

Pavlovian Laboratory of the Phipps Psychiatric Clinic
Johns Hopkins University School of Medicine

P. S. Please use the self-addressed envelope (which needs no postage) for reply.

Lascaux Charcoal

We have noticed with great interest the comment of Don Ritchie (*Science*, **113**, 531 [1951]) concerning the identification of charcoal fragments from the Lascaux Cave, near Montignac, Dordogne, listed as sample #406 in the paper by Arnold and Libby (*Science*, **113**, 111 [1951]) on radiocarbon dates, where it was stated that the charcoal was ". . . of conifer *Abies* or *Larix*, neither of which grows in a cold climate." As Dr. Ritchie points out, this statement was made in error; it should have read ". . . neither of which is necessarily indicative of arctic conditions."

Subsequent analysis of the Lascaux sample by one of us (ESB) reveals that there is no reason to doubt that the wood is that of the genus *Abies* (fir). In all its details of structure this charcoal can be matched with the wood of *Abies pectinata* DC., the European silver fir. Structure of the torus of the bordered pits and the form, size, and number of the pits between ray cells and tracheids are identical with those of this species. The specimen consists of a small branch or stem with exceptionally narrow growth rings, indicative of very slow growth. It is more likely a branch than a young stem, in view of the prevailing orientation of the rays to the tracheids, these not being at right angles as is normal in erect stems.

Whether the charcoal is from the wood of *Abies pectinata* or some other species of *Abies* is not possible to determine for certain. In fact, it is extremely difficult, if at all possible, to determine as to species the wood, much less charcoal, of the various species of *Abies*. In view, however, of the present range and occurrence of *A. pectinata*, and the fact that the charcoal wood differs in no detectable way from this species, it seems reasonable to conclude that it is *A. pectinata*.

A. pectinata is widespread in the forests of central Europe, where today it forms a major component in the montane forests of parts of Germany, Austria, France, and the Swiss mountains. It occurs as far south as Corsica and the Pyrenees. The presence of this form in the Vézère Valley at the time the Lascaux Cave was occupied by late Upper Palaeolithic man indicates that a slightly more rigorous climate obtained than that now characteristic of this area, since the flora then contained elements thriving at present in the adjacent truly alpine regions. In terms of climatic tolerance *A. pectinata* is stated to have nearly the same degree of cold tolerance as the common European beech *Fagus sylvatica*.

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Stability of Disodium Adenosine Triphosphate[1]

Recent reports on the stability of various preparations of ATP[2] have been conflicting. Bailey (*1*), using enzymatic methods of assay, found that metallic salts of ATP decompose on storage to AMP[1] and inorganic pyrophosphate, and to a lesser extent to ADP[2] and inorganic orthophosphate. Rowles and Stocken (*2*), who also employed enzymatic methods, found that a specimen of dibarium ATP stored at room temperature for over two years had formed inorganic pyrophosphate to the extent of 3%, as compared with a value of 41% for a comparable sample reported by Bailey.

A new approach to the analysis of adenosine polyphosphates has been developed by Cohn and Carter (*3*), who introduced the use of ion-exchange resins for this assay. In analyzing various commercial ATP preparations, these investigators noted that a tetrasodium salt, Na_4ATP, which had been stored at room temperature for six months, had decomposed practically completely to AMP, whereas a similar preparation, stored at −35° C, retained a high ATP content. They state that the instability of the sodium salt of ATP has been noted by others and makes im-

[1] We wish to thank J. W. Williams, R. A. Alberty, and R. M. Bock, of the University of Wisconsin, for their cooperation in this work.

[2] ATP, adenosine triphosphate; ADP, adenosine diphosphate; AMP, adenosine monophosphate.

perative the analytical control of this compound before use.

A new form of ATP, the disodium salt $Na_2H_2ATP \cdot 4H_2O$, has recently been developed in these laboratories, and its stability has been under investigation for the past six months. We are reporting the preliminary results of this study, which will be of interest to the increasing number of research investigations being conducted with ATP.

As a method of analysis, the ion-exchange technique of Cohn and Carter (*3*) was employed. In order to check this method by a completely independent technique, a comparison with the moving boundary (electrophoresis) procedure of Bock and Alberty (*4*) was conducted. Both methods were found to agree to within ±5%, the resin method tending to give slightly lower ATP values.

Samples of disodium and dibarium ATP were stored at 25° C, 4° C and −20° C, and assayed for ATP content after various periods of time. At 25° C, a progressive decrease in ATP content, amounting to about 3% per month for both salts, was noted. This decomposition was found to be associated with the development of ADP, AMP, and inorganic orthophosphate (pyrophosphate was not investigated). At both 4° C and −20° C, however, no significant changes in ATP content could be detected.

From the data thus far obtained, it is concluded that disodium and dibarium ATP are stable at temperatures of 4° C, or lower, but decompose at the rate of about 3% per month when stored at 25° C. There appears to be no difference in the stability of the disodium salt as compared with the dibarium salt. It is suggested that metallic salts of ATP be stored in a dry atmosphere at low temperature, under which conditions they appear to be perfectly stable.

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Book Reviews

Quantum Mechanics. Alfred Landé. New York: Pitman Pub., 1951. 307 pp. $5.50.

Perturbation Methods in the Quantum Mechanics of n-Electron Systems. E. M. Corson. New York: Hafner Pub., 1950. 308 pp. $11.00.

The development of quantum mechanics in the past half century has made it a firm foundation for the discussion of atomic, molecular, and even nuclear phenomena, whenever velocities can be regarded as small compared to the velocity of light and the constituent particles do not change in numbers. The frontiers of theoretical knowledge lie in the related problems of relativistic invariance, transformations of the ultimate particles, and the field theory of the forces between them. The practical application of the settled theory is limited by the complication of dealing with many body problems.

It is now customary to introduce students of physics to some quantum mechanics in their last undergraduate years and first graduate year, and several excellent textbooks for such courses are available. For an advanced course, however, it has, to a large extent, been necessary for the professor to bridge the gap between these elementary texts and the advanced monographs and original literature. The two books considered here seem to fill most of this gap very well.

Landé's book seeks to build up an approach to the understanding and solution of problems in the field from the physical picture. He adopts a historical arrangement, showing in his first 7 chapters how quantum mechanics develops from the equivalence of wave and particle descriptions—explaining approximate methods of solving the wave equation, and developing the technique of matrix mechanics in an intuitive manner. In the second half of the book he lays the groundwork for a large number of physical applications: elementary radiation theory, including photo-ionization and coherent and Raman scattering; atomic spectra, including the details of the helium spectrum and fine structure and Zeeman effect in general; molecular structure and molecular spectra, including the Heitler and London theory of the hydrogen molecule; an introduction to statistical methods, dealing with the Bose and Fermi gases and with fluctuations; the Dirac electron and relativity theory; the quantum theory of radiation; and the meson theory of nuclear forces. In all this the emphasis is on the physical picture behind the mathematical equations, which, in the frontier examples, we may hope will remain when the present mathematical difficulties have been overcome.

Corson's book will carry the student who already has an idea of the physical pictures involved over the whole range of exact and approximate mathematical solution of problems in the quantum mechanics of many particles. It is thus more advanced and more complete in itself, but a little more restricted in range than Landé's book. The author develops the general theory by the methods of Dirac, mathemati-

cally rigorous for problems involving discrete states, but assuming the natural extension to continuous spectra. Having so introduced Hermitian operators on vectors to describe observables and states in various representations, and the canonical equations of time change, he next deals with the application of group theory to give exact transformations for simplifying problems, and with perturbation theory in general. Then follow chapters on the methods of approximate solution: orbitals, variational methods, the Hartree-Fock equations, statistical fields, and the vector model for many-electron problems treated in detail by Dirac's methods, including applications to molecular structure. Finally, Corson deals with subjects at the frontier; second quantization and Heisenberg's *s*-matrix theory. To cover the material dealt with so well in this book would previously have required reading at least three monographs, as well as original literature.

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Stratigraphy and Sedimentation. W. C. Krumbein and L. L. Sloss. San Francisco: Freeman, 1951. 497 pp. $5.00.

It is truly remarkable that in spite of rapid advances and the immense practical importance of stratigraphy, no general textbook has heretofore covered this field since Grabau's *Principles of Stratigraphy* in 1913. It is equally noteworthy that the present volume could hardly have been written more than a decade ago, for its viewpoint and substance have been strongly molded by recent advances in which its authors have played an active part.

Although the purpose of the book is clearly to interpret the stratified rocks, almost half its pages are devoted to sedimentary petrology and sedimentation. This is quite proper, of course, for materials and processes must be understood before rocks can be interpreted. The attempt to cover so wide a range of subject matter in a single volume must have imposed many difficult choices, and perhaps no one will regret that the book is rather heavily weighted in the aspects of stratigraphy in which the Northwestern school has recently been so much engrossed.

Following a brief introduction, Chapter 2 reviews the history of the geologic column and of our system of classifying the stratigraphic record. Here the reader encounters two viewpoints, which run through the book and will be warmly approved. One is the awareness that stratigraphy is a young and growing science in which ideas are still in flux; the other is consciousness of the problems arising out of the practical application of stratigraphy to the search for petroleum—especially in subsurface exploration.

Chapter 3 describes stratigraphic procedures, and Chapters 4–7 deal with various aspects of sedimentary petrology and processes of sedimentation. Chapters 8 and 9, devoted to stratigraphic paleontology and sedimentary facies, respectively, form a necessary prelude to the discussion of the principles of correlation covered in Chapter 10.

Chapters 11 and 12 develop the idea that the nature of a sedimentary deposit is largely determined by the tectonic framework in which it is formed, as well as the stage in the tectonic cycle. These chapters, synthesizing recent advances in philosophical interpretation, are perhaps the most thought-provoking in the book.

It is, of course, inevitable that, in a completely new treatment of a field so broad and controversial, other specialists will question some of the terminology and some of the interpretations. Indeed, one of the most wholesome aspects of the book is the frequence with which its authors indicate a tolerance for other interpretations. This is not the place to debate such problems, but a sample may serve to illustrate their nature. In discussing the tectonic framework of sedimentation, ***shelf areas*** are defined (p. 338) as

> the most neutral or stable parts of the craton, lying between and among the more postive or negative areas. The term applies to a degree of tectonism, and not to specific geographic areas. Present continental margins are shelves, but, in a stratigraphic sense, the term refers to any portion of the craton which displays no marked tectonism during a major cycle of deposition.

A further distinction is made between the ***stable shelf***, which is "the most neutral part of the craton," and the ***unstable shelf***, which is characterized by "slight oscillatory movements" that "commonly give rise to cyclical sedimentation." In view of the long-standing and widespread use of the term "shelf" in a different geological sense, this usage can hardly avoid misunderstanding and confusion. Certainly, the continental shelf off California has not been stable during recent geologic time, and that along the Gulf Coast has been rapidly subsiding. Neither of these regions could be accepted as ***shelf*** in the stratigraphic sense. Furthermore, the idea of shelf seas lying over the continental shelf is so deeply ingrained in geologic literature that to speak of the Illinois coal fields as having formed on a shelf would be confusing.

It is difficult to accept the generalization (p. 210) that "in the deeper parts of the neritic environment, clastic sediments are usually subordinate," and that "limestone may occur in great variety." The modern neritic sea floors certainly are generally covered with terrigenous muds or sands, except for limited areas.

In the attempt to be brief yet circumspect, the authors seem, in places, to be thinking rather more of their professional colleagues than of the student. On page 1, for example, stratigraphy is defined as "the integrating science which combines data from all other branches of earth science in a form from which historical geology emerges as a natural product." Probably only a very alert student would quickly translate this to mean that stratigraphy is the study of strata! Close reasoning in technical jargon perhaps inevitably demands close concentration, as on page 384, where we read: "The sedimentary environment is of strongest importance in controlling the detailed patterns of sediment distribution." But it would be unfair and un-

gracious to emphasize such difficult passages rather than the challenging and stimulating features of the book, not the least of which are the many well-chosen and effectively used illustrations. It goes without saying that the Krumbein and Sloss text will be warmly welcomed both by students and by professional stratigraphers.

CARL O. DUNBAR

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The Origin of the Earth. W. M. Smart. New York: Cambridge Univ. Press, 1951. 239 pp. $2.75.

This book should prove to be a much-needed antidote to Hoyle's *The Nature of the Universe,* and it is gratifying to find a scientist who is not ashamed to confess that to him "the Heavens are telling the Glory of God and the Wonder of His Works." The book is nontechnical and can be read without any difficulty by the intelligent layman. It found its origin in talks given to servicemen and other lay audiences during and immediately after the second world war.

The book suffers somewhat from this transition from the spoken to the written word, and insufficient attention has been paid to the fact that statements made in print should be much more carefully weighed than those made in lectures. The result is a rather unbalanced presentation that, although not containing any apparent inaccuracies, gives a large number of half-truths which in a popular book of this kind should be avoided at all cost. This makes it difficult to recommend the book for popular reading.

There are quite a number of points that should be commented upon, but I shall restrict myself to a few remarks concerning Chapter IX, which discusses various theories of the origin of the solar system. It is clear that Professor Smart tried to steer clear of controversial points, but in doing so he gives a partial and inadequate picture.

First of all, the author makes the all-too-common mistake of lumping the Kant and Laplace theories together. As a result, he states that von Weizsäcker's theory is based on Laplace's, whereas it is clearly a variant of Kant's theory. The picture of von Weizsäcker's theory is incorrect and seems to borrow from Whipple. (By the way, why mention Hoyle's theory and not Whipple's?) The essential ideas of the theory attributed to Gunn were expounded in 1941 by Lyttleton. It should also have been mentioned that Birkeland (1912) and Berlage (1927) considered electromagnetic forces long before Alfvén. Finally, Spitzer's objections to dualistic theories should have been mentioned, since they dispose rather decisively of all dualistic theories.

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Genetic Neurology: Problems of the Development, Growth, and Regeneration of the Nervous System and of its Functions. Conference sponsored by the International Union of Biological Sciences. Paul Weiss, Ed. Chicago: Univ. of Chicago Press, 1950. 239 pp. $5.00.

This volume consists of a collection of essays written by the speakers at the International Conference on the Development, Growth, and Regeneration of the Nervous System held in Chicago in 1949. In the foreword and the first chapter P. Weiss, conference chairman, gives an account of the subjects discussed during the meetings, with his comments. The essays, which differ greatly in form, scope, and content, present:

A clear and concise review on the colloidal organization of the nerve fiber by F. O. Schmitt; a commentary to a motion picture (which can be rented or bought from the Wistar Institute) of neurons and neuroglia in tissue culture by W. H. Lewis; an account of the factors influencing the path of nerve growth and of the reciprocal influence of the lateral-line nerve fibers and organs in frog tadpoles by C. C. Speidel; an excellent review on certain aspects of nerve regeneration from a histological viewpoint—unfortunately, without any illustrations—by J. Boeke; an account of some factors influencing the size of nerve fibers and of the problem of internode length by J. Z. Young; an article on regeneration of peripheral nerves in man by S. Sunderland; a lucid and very stimulating article on differentiation of nerve cells and nerve centers by V. Hamburger and R. Levi-Montalcini; a discussion of limitations of the methods used in neuroembryology by J. Piatt; and a review of the results of spectroscopic studies on nerve cells of H. Hydén.

There is an excellent report on cytological and biochemical changes during maturation of nerve cells, and on the correlation of these changes with the onset of electrical activity, by L. B. Flexner; a stimulating review of certain aspects of neural growth and regeneration by R. W. Gerard; a discussion of neural growth, the development of behavior, and spinal cord regeneration by D. Hooker; a review of the development of reflex movements in mammals by W. F. Windle; an article attempting to resolve the present controversy regarding the development of integrative capacity of the nervous system in vertebrates by D. H. Barron; an article on neuronal specificity by R. W. Sperry; a discussion of neuron diversity by D. Bodian; and, finally, a report on the development of Mauthner's cell and one on regeneration in the central nervous systems of urodeles and reptiles by A. Stefanelli.

On the whole, the book provides highly stimulating material, although it is not always easy to read. A number of challenging problems are advanced which are likely to lead to fruitful controversies. The title of the volume, unfortunately, does not give a real indication of its actual content. As it is, the book may be missed by some who would appreciate the essays, and it may be disappointing to others who would expect an organized presentation of the entire subject.

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News and Notes

Scientists in the News

Frederick deWolfe Bolman, Jr., of New York City, has taken office as president of the Jamestown Community College of the State University of New York. The school was founded a year ago as the first community college in New York under the supervision of the State University.

Needham, Louis & Brorby, Inc., Chicago advertising agency, has named the psychologist **Steuart Henderson Britt** vice president and director of research. He formerly was director of personnel at McCann-Erickson.

Henry J. Bruman, associate professor in the UCLA Department of Geography, will spend a year in the Dominican Republic, Brazil, Argentina, Paraguay, Bolivia, Peru, and Venezuela. From his findings, he will make recommendations concerning areas and techniques for future colonization. Two thirds of his time will be devoted to a study of the colonization problems of Brazil.

Louis W. Busse, professor of pharmacy at the University of Wisconsin, is the 1951 winner of the Ebert prize in pharmacy, and his colleague, **Takeru Higuchi,** has been awarded the certificate of honorable mention. The awards were given in recognition of work on physicochemical aspects of pharmacy, with specific reference to research on "The Application of Spray Drying Techniques to Pharmaceutical Powders" and "Heat Sterilization of Thermally Labile Solutions." The Ebert prize was established in 1873 by Albert Ethelbert Ebert, a pharmacist and chemist, for the "best essay or written contribution containing an original investigation of a medicinal substance, . . . or for improved methods . . . for the preparation of chemical or pharmacal products."

Paul L. Copeland has been appointed acting chairman of the Physics Department at Illinois Institute of Technology, temporarily filling the vacancy left by the recent death of **James S. Thompson,** chairman of the department for 17 years. **Marion H. Groves** has been appointed assistant to William A. Lewis, dean of the graduate school. Dr. Groves has been assistant professor of psychology at the institute for the past year. From 1943 to 1945 he was chief psychologist for the Cook County Criminal Court Behavior clinic. Later he served as an instructor in psychology at the universities of Chicago and California.

William Wellesley Demeritt, Jr., head of the Department of Pedodontics in the University of Southern California, Los Angeles, has been appointed to that position in the University of North Carolina School of Dentistry.

Gunnar Dybwad has been appointed director of the Child Study Association of America. He has been head of the children's division of the Michigan State Department of Social Welfare.

Freeman J. Dyson, British theoretical physicist, has been appointed professor of physics at Cornell University. Since 1949 Dr. Dyson has been a Warren Research fellow at the University of Birmingham. He came to the U. S. on a Commonwealth Fellowship in 1946 and spent the following four years in study at Cornell and at the Institute for Advanced Study.

Antonio Ferri, who came to this country during World War II, to do research under OSS auspices, has been appointed professor of aerodynamics at the Polytechnic Institute of Brooklyn. Dr. Ferri will carry out a program in aerodynamics under the sponsorship of the Department of Defense. He will also teach graduate courses in compressible flow and supersonic wing theory.

John F. Fulton, Sterling professor of the history of medicine at Yale University, is serving as exchange professor of physiology at Belgium's University of Louvain under the sponsorship of the Belgian Francqui Foundation. He will also deliver a Sherrington Lecture at the University of Liverpool. The Sherrington Lectures were founded in honor of Charles Sherrington, professor of physiology at Liverpool from 1895 to 1913. Dr. Fulton is the second outstanding medical authority to deliver a Sherrington Lecture. He will act as the official Yale representative at the centennial celebration of the Higher Philosophical Institute at the University of Louvain, in honor of the late Cardinal Desire Mercier, founder of Louvain.

Ragnar Granit, director of the Nobel Institute for Neurophysiology, Karolinska Institutet, Stockholm, is traveling in the U. S. and Canada under the auspices of the Rockefeller Foundation.

T. Swann Harding, editor and writer, with more than 37 years of varied services in the U. S. Department of Agriculture, has retired. Since 1943, Mr. Harding has been the editor of *USDA,* the employee news bulletin.

Ralph P. Hudson, former assistant professor of physics at Purdue, has been appointed to the research staff of the National Bureau of Standards to carry on work in low-temperature physics.

Joyce W. Kingsley, formerly of the Department of Medicine at the Lahey Clinic, Boston, and subsequently associate physician at the Blain Clinic, has been appointed physician-in-chief to the Alexander Blain Hospital, Detroit.

Raymond Laird, associate professor of preventive medicine at the University of Tennessee Medical Units, has resigned, to become chief consultant on malaria

control in Burma for ECA. He also will help medical schools in the area in developing medical programs in the field of preventive medicine.

Sidney I. Miller has been appointed instructor in chemistry at Illinois Institute of Technology. For the past year Dr. Miller has been an instructor at the University of Michigan.

J. J. Quilligan, formerly associated with Thomas Francis at the University of Michigan, is joining the staffs of the Texas Children's Hospital and the Southwestern Medical School.

William Reiner-Deutsch has been appointed director of laboratory research, New York Eye and Ear Infirmary. He has been associated with that institution since August 1950.

Chauncey O. Rowe has been appointed vice president of the Institute of Inter-American Affairs. From 1949 to May 1951, he was deputy director of the Office of Personnel in the State Department. Recently he completed a nine-month executive recruitment program for the department and has traveled in South America on special assignments as the representative of the Under Secretary of State.

Morris Scherago has been designated as Distinguished Professor of the year 1950–51 at the University of Kentucky. The honored professor customarily is granted a term free from teaching duties in order that he may give full time to some research project and prepare the annual Arts and Sciences lecture.

George A. Silver has been appointed full-time chief of the social medicine division of Montefiore Hospital. Since 1948 Dr. Silver has been health officer of Baltimore. He has been a member of the Johns Hopkins University School of Hygiene.

G. Fred Somers has been named associate director of the University of Delaware Agricultural Experiment Station. Dr. Somers, who has been assistant director of the U. S. Plant, Soil, and Nutrition Laboratory and associate professor of biochemistry at Cornell University, will coordinate the farm research program, as well as conduct special studies.

S. E. Sulkin received the 1950 Dallas Health Service Award presented annually by the Dallas County Hospital Council "for his practical demonstration that better health makes a better community."

A. R. Todd, professor of chemistry, University Chemical Laboratory, Cambridge, England, delivered the first Harvey Lecture of the current series at the New York Academy of Medicine on September 27. Dr. Todd spoke on "The Nucleotides: Recent Chemical Research and its Biological Implications."

Harry C. Trelogan has been appointed assistant administrator of the Agricultural Research Administration. Dr. Trelogan will be responsible for marketing work under the Research and Marketing Act, which was previously directed by **Omer W. Herrmann,** who resigned June 1 to head the Department of State's agricultural work at the American Embassy in Paris.

K. Wieland, of the University of Zurich, will spend the next year at the Physics Department of the University of California.

After 47 years of teaching, **Ernest Clair Witham** retired as professor of education from Rutgers University School of Education, where he taught 22 years. He is a member of the Board of Education of Raritan Township and Middlesex County representative on the State Federation of Boards of Education.

Jacob Wolfowitz has been named professor of mathematics at Cornell University. He has been at Columbia University since 1946 and has also taught at the University of North Carolina.

Education

Illinois Institute of Technology will dedicate its Freund Instrumentation Laboratory this month. Named in memory of Erwin O. Freund, founder of the Visking Corporation, the laboratory was established in 1948 by Martin Kilpatrick, chemistry chairman. The annual Freund scholarship has been awarded to Charles B. Arends, of Chicago, and the annual Freund fellowship to Morton J. Klein, of Chicago.

Oak Ridge Institute of Nuclear Studies will give a course in the techniques of preparing problems for high-speed digital computing machinery Dec. 3–14. The Oak Ridge National Laboratory machine, around which the course will be centered, is to be an electronic automatic computer, single-address type, patterned after the one at the Institute for Advanced Study. Alston S. Householder, chief of the Mathematics Panel at Oak Ridge, will direct the course, which will be limited to 30 participants. Application blanks and additional information may be obtained from Ralph T. Overman, Oak Ridge.

Ohio State University has named Frederic W. Heimberger vice president, succeeding Harlan Hatcher. John A. Ramseyer, who has headed the University School since 1946, will direct the five-year School-Community Study Project established by a grant last spring from the Kellogg Foundation (SCIENCE, **113,** 471 [1951]). The Ohio State project (one of six in a nation-wide survey financed by Kellogg) will enlist the cooperation of six other Ohio universities: Akron, Miami, Ohio, Cincinnati, Bowling Green, and Kent State.

Beginning this month, **Saint Joseph's College** will offer a five-year cooperative curriculum leading to the B.S. in electronic physics. Through agreement with five major industries in the Philadelphia area, qualified students will spend alternate three-month periods in their plants. The exchange will continue for twelve quarters until graduation.

The **University of Tennessee** College of Medicine will celebrate the centennial of medical education in Tennessee on Oct. 4, when it dedicates its new Cancer Research Laboratory and the Institute of Pathology. John W. Cline, president of the AMA, will deliver the principal address. Other speakers will be Robert A. Moore, Alan T. Waterman, Leonard A. Scheele, Cornelius P. Rhoads, Henry K. Beecher, and Edward A. Doisy. The university will also celebrate a $4,800,000 expansion program, which calls for two new buildings, and remodeling and enlargement of others. It will enable the college to admit 50 freshman students each quarter instead of 35, as at present.

Three units of the $100,000,000 **Texas Medical Center**, Houston, are already operating. They are Baylor University College of Medicine, the Hermann Hospital, and the Hermann Professional Building. Work is progressing on the Methodist Hospital, the Arabia Temple Shrine Crippled Children's Clinic, and the University of Texas M. D. Anderson Hospital for Cancer Research. Other projects under way or planned are a postgraduate school of medicine and a school of public health and geographic medicine for the University of Texas, the Texas Children's Hospital and St. Luke's Episcopal Hospital, a new city-county general charity hospital, a University of Houston building to house its college of nursing, school of pharmacy, and a projected school of hospital administration. The Houston Academy of Medicine is planning a central medical library for the center. The major portion of the 163-acre tract was donated by the M. D. Anderson Foundation, which also provided millions of dollars in funds. H. R. Cullen, Houston oilman and philanthropist, also contributed large sums to the center.

Grants and Fellowships

First recipient of the $5,000 **McCallum Fellowship** was Arthur L. Babson, of Metuchen, N. J. He will work at Rutgers University in the Department of Physiology and Biochemistry, specializing in the nutritional factors affecting cancer.

The **Merck Board of Directors' Scientific Award**, recently established as a way of honoring company scientists for outstanding achievements, has gone to Karl Folkers, Lewis H. Sarett, and Max Tishler. Dr. Folkers has selected the universities of Illinois and Wisconsin as recipients of grants from Merck. Illinois will offer a series of annual lectures, to be known as the Karl Folkers Lecture Series in Chemistry. Dr. Tishler chose Tufts College and Harvard as the educational institutions to receive grants. At Harvard the Max Tishler Lectures in Chemistry will offer an annual guest speaker. Dr. Sarett's selection of universities was Northwestern and Princeton, where plans are still in the formative stage for use of the funds from Merck.

Among the first awards made by the **National Institute of Arthritis and Metabolic Diseases** was a sum of $90,000 to the University of Utah, for investigation of muscular dystrophy under the direction of Maxwell M. Wintrobe. Tulane University received $30,132 for work on the B vitamins under Grace A. Goldsmith, and the Robert Breck Brigham Hospital, Boston, $14,472 for investigation of high-dosage cortisone therapy in rheumatic diseases. A total of $314,465 was awarded.

Pittsburgh Corning Corporation is participating in the establishment of a Co-ordinated Classroom Fellowship at Stanford University. The new fellowship is devoted to the study of the effects of physical environment in the classroom upon the development, health, and learning of school children. First recipient is A. Blaine Huntsman, dean of boys at Pocatello (Idaho) High School.

Playtex Park Research Institute, sponsored by the International Latex Corporation, has announced four pediatric research grants in addition to twelve previously made: to New York University–Bellevue Medical Center for studies of amino acid metabolism; to Montefiore Hospital for studies of blood vessel grafts and vascular shunts in pediatric surgery; to Cornell University Medical College for a study of kidney function in infants; and a continuation of a grant to Columbia University College of Physicians and Surgeons for an investigation of hormonal control of water and electrolyte balance in premature infants. A large number of additional grants for medical research in the field of child health are planned by the new foundation.

Under a special grant from the **Rockefeller Foundation**, the Conservation Foundation has launched a new project to determine the types of research needed to discover additional sources of marine plant and animal life of use economically or otherwise to human progress. Lionel Walford, aquatic biologist on leave from the U. S. Fish and Wildlife Service, will direct the investigation.

In the Laboratories

Among new laboratories being built or planned are the **Armour Research Foundation** $600,000 Mechanics Research Building, which will provide space for 200 scientists and engineers; the **Celanese Corporation** $500,000 laboratory at Clarkwood, Texas, for research on chemical production from petroleum raw materials; and the **Dow Chemical Co.** research facilities at Midland, Mich., and Freeport, Texas, to cost some $4,500,000. The Midland project will include new organic spectroscopy research, special-service laboratories, and a technical library; an eight-building research center will be constructed at Freeport.

The **Atomic Energy Commission** has accepted proposals from Bendix Aviation Corporation and Tracerlab, Inc., for the study of the commercial feasibility of manufacturing, processing, and selling radioisotopes. Both firms are to make their reports to the AEC within a year. The commission is not at this time

able, however, to consider additional proposals of this type.

Bausch & Lomb Optical Company has formed a Defense Contract Department to handle the increase in number of military contracts. Kenneth E. Reynolds, a physics instructor at Armour Institute before joining Bausch & Lomb in 1937, will head the new department.

Bowser, Inc., of Chicago, has acquired ownership of **National Scientific Laboratories, Inc.,** of Washington. Robert I. Sarbacher, National Scientific president and former dean of the graduate school of Georgia Tech, has been appointed director of research and will head product development. Immediate projects include new coin- and currency-counting and -handling devices and new automotive testing equipment.

A new research division in the Bureau of Entomology and Plant Quarantine, in which research will be conducted on the control of insects that destroy stored products, will be known as the **Division of Stored Product Insect Investigations.** Randall Latta has been designated acting leader, and R. T. Cotton and Lyman S. Henderson, assistants. One phase of the research will deal with the control of insects that cause problems during manufacturing or processing, a comparatively new field. This work will center at the bureau laboratory at Savannah, Ga. The present USDA Division of Control Investigations at Beltsville, Md., will also be incorporated in the new division.

Donald E. Sargent has joined the organic chemistry division of the **General Electric Research Laboratory.** He has done chemical research with Du Pont, General Aniline & Film Corp., and with Olin Industries, Inc.

New staff appointments at **The Johns Hopkins University Applied Physics Laboratory** include the following physicists: Julius L. Jackson, Perry J. Luke, Milton J. Moon, Harold M. Nicholson, Philip Rosen, Harold D. Smith, Angus C. Tregidga, and Anthony J. Wilk. New staff mathematicians are Sholom Artz, Nelson A. Brigham, George G. Murray, Jr., John L. Vanderslice, and Mathews C. Waddell.

Roy E. Morse, formerly head of the Food Technology Laboratories of the Monsanto Chemical Company, has joined **Kingan and Company,** of Indianapolis, as director of research.

North American Philips Company will hold its semiannual X-Ray Diffraction School at its plant in Mt. Vernon, N. Y., Oct. 8–12. The schedule includes discussions by I. Fankuchen, Brooklyn Polytechnic; Herbert S. Fried, NRL; A. C. van Dorsten, of the Holland Philips organization; William Parrish and E. A. Hamacher, Philips Laboratories, Irvington, N. Y.; C. L. Christ, U. S. Geological Survey; John T. Norton, MIT; W. O. Milligan, Rice Institute; David Harker, Brooklyn Polytechnic; and A. L. Patterson, Institute for Cancer Research.

Meetings and Elections

At a meeting in June at the Chicago Natural History Museum, the **American Society of Ichthyologists** elected John Treadwell Nichols and Helen T. Gaige honorary presidents, George S. Myers president, and John Tee-Van, George P. Meade, and George A. Moore, vice presidents. Dwight A. Webster was elected treasurer, and Ed. C. Raney secretary.

The **International Association of Seismology and Physics of the Earth's Interior** has elected Beno Gutenberg, of Caltech, first president, to serve a three-year term. Dr. Gutenberg had been president of the International Committee on Physics of the Earth's Interior, which was merged with the new association at the recent Brussels meeting. While abroad the Caltech professor of geophysics visited Paris, Turkey, and Israel, where he consulted with Israeli scientists on installation of seismological instruments.

A **Research Conference on Crustacean Hormones** was held in August at the Woods Hole Marine Biological Laboratory, at which the following presented papers: L. M. Passano, D. E. Bliss, L. H. Kleinholz, D. F. Travis, E. Kuntz, and M. I. Sandeen, H. M. Webb, and F. A. Brown, Jr. It is expected that abstracts of the research reported at the conference will soon be published.

J. Claire Evans, president of the Denver Fire Clay Company, has been elected president of the **Scientific Apparatus Makers Association,** and Edward J. Albert was named president pro tempore. T. M. Mints was re-elected treasurer, and Charles S. Redding, president of Leeds & Northrup, who was president for two years, was elected one of the six directors-at-large, who are also members of the Board of Directors. Kenneth Andersen, of the permanent staff, was reappointed executive vice president and re-elected secretary.

Those attending the fourth annual **Scientific Meeting of the Detroit Institute of Cancer Research** will have an opportunity to hear addresses by such authorities as C. H. Best, James B. Brown, Erwin Chargaff, V. du Vigneaud, C. D. Haagansen, Michael Heidelberger, M. J. Kopac, I. T. Nathanson, Hans Neurath, Alton Ochsner, K. R. Porter, and Hans Selye. The sessions will be held in the Engineering Society auditorium, Horace H. Rackham Educational Memorial, Oct. 22–24.

The second **Symposium on Chemical-Biological Correlation,** being organized by the Chemical-Biological Coordination Center of the National Research Council, will be held at the National Academy of Sciences Oct. 24–25. The Program Committee, of which C. P. Huttrer is chairman, would like to include in the program at least one scientific movie that deals specifically with the effect of chemicals upon biological systems, such as organisms, organs, tissues, cells, etc. Information as to such movies should be sent to the center, 2101 Constitution Ave., Washington 25, D. C.

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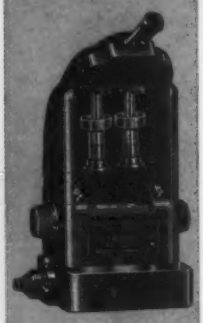

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Oct. 17–19. American Association of Textile Chemists and Colorists. Hotel Statler, New York.
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Oct. 22–23. Independent Petroleum Association of America (Annual). The Shamrock, Houston, Tex.
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Oct. 22–24. Packaging Institute (Annual). Hotel Commodore, New York.
Oct. 22–25. American Academy of Pediatrics (Annual). Royal York Hotel, Toronto.
Oct. 22–26. American Institute of Electrical Engineers (Fall). Hotel Cleveland, Cleveland.
Oct. 23. Association of Consulting Chemists and Chemical Engineers (Annual). New York.
Oct. 23–24. Optical Society of America (Annual). Hotel Sherman, Chicago.
Oct. 24–27. American Physical Society. Chicago.
Oct. 25. Society of Exploration Geophysicists (Eastern). Webster Hall Hotel, Pittsburgh.
Oct. 25–26. American Institute of Mining and Metallurgical Engineers (Annual fall, Petroleum Branch). Elks Club, Los Angeles.
Oct. 29–30. Society of Automotive Engineers (National Diesel Engine meeting), The Drake, Chicago; (National Transportation), Knickerbocker Hotel, Chicago, Oct. 29–31; (National Fuels and Lubricants), The Drake, Oct. 31–Nov. 1.
Oct. 29–31. Conference on Electrical Insulation (Annual). National Bureau of Standards, Washington.
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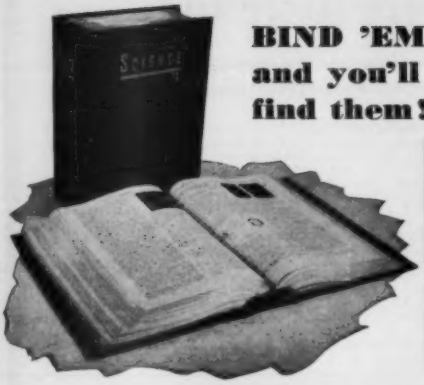

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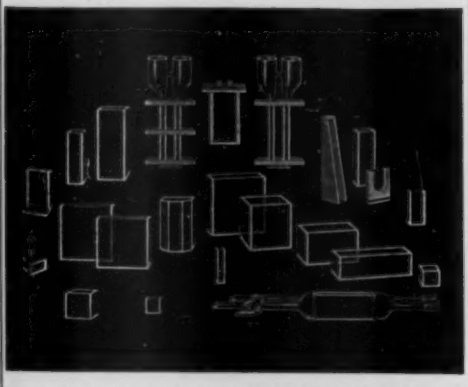

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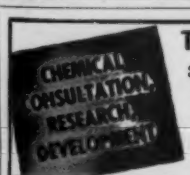

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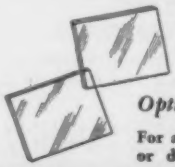

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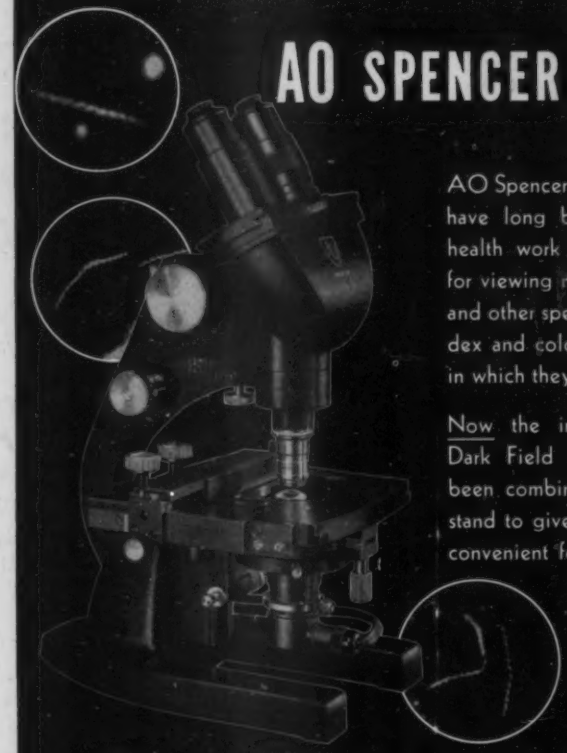

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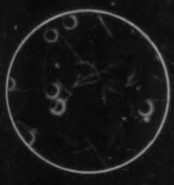

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